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Cover: Fisher (*Martes pennanti*) photographed December 1979 beside a White-tailed Deer (*Odocoileus virginianus*) carcass in Algonquin Provincial Park, Ontario, by Ronald Ridout: see note by Ronald J. Pittaway (p. 57) on scent marking behaviour.

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Population Ecology of Sciurids in Northwestern Minnesota

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A 22-year study of population dynamics for *Spermophilus tridecemlineatus, S. franklinii, Tamias striatus, Eutamias minimus,* and *Tamiasciurus hudsonicus* was conducted in northwestern Minnesota from 1954-1975. Changes in density may be cyclic. *S. franklinii* provided the strongest case for periodicity, but causal mechanisms are unclear. Data are presented suggesting that *S. franklinii* may be involved in the snowshoe hare (*Lepus americanus*) — vegetation hypothesis (Keith 1974). Life tables and survivorship curves suggest age-independent survival among middle age classes with higher mortality for juveniles and old individuals.

Key Words: Sciuridae, population dynamics, cycles, life tables, survivorship

Population dynamics of *Spermophilus tridecemlineatus*, Thirteen-lined Ground Squirrel, *S. franklinii*, Franklin's Ground Squirrel, *Tamias striatus*, Eastern Chipmunk, *Eutamias minimus*, Least Chipmunk, and *Tamiasciurus hudsonicus*, Red Squirrel, were studied for 22 years on the campus of the University of Minnesota Forestry and Biological Station in northwestern Minnesota as a class project beginning in 1954. Objectives were mainly to provide students with experience in field methods and data handling. However, as results were evaluated over the years, we realized that a unique data base with respect to the population biology of small mammals was developing. This paper provides insight into fluctuations in population density of these species and presents basic demographic parameters such as sex ratios, life expectancy and survival curves. In addition, yearly fluctuations in population density of each species are examined with reference to cycles.

Methods

The study site is located within Itasca State Park in Clearwater County, Minnesota, T143N, R36W, Sec. 2. Vegetation of the Park is a mixed coniferous-deciduous forest (Hanson et al. 1974). A mixture of forest and grass-herb habitats characterizes the Forestry and Biological Station. Numerous openings have been artifically created and maintained. Most notable is a grass athletic field of about 0.1 ha. Considerable edge between grassland and forest exists because of disturbance by man, and adds to the heterogeneity. Soil type for this area is termed a Nebish Variant-Unnamed association (U.S. Department of Agriculture 1975).

National live traps (13.2 ± 3.2 per species) baited with peanut butter were used on the 20-ha campus for three weeks each summer from 1955 through 1975. A few individuals were captured in 1954 in a pilot study. Sex, weight, and reproductive status were determined for each individual sciurid caught, and ear tags (1954-56) or toe clipping (1957-75) and hair dye (Miss Clairol Velvet Black mixed 50:50 with H_2O_2) were applied as permanent and temporary identification marks, respectively. Mean effort (± S.D.) in trap-days per year was 1026 ± 171 for the five species combined. Traps, which were not selective for species, were set in areas containing sign or where animals had been captured in previous years. By the third week of trapping nearly all individuals captured had been marked previously.

For all aspects of the analysis except survivorship, only data on adults captured from 10 June through 20 July were used; therefore, data from 1965 and 1971, when trapping was conducted only after 20 July, were excluded from the life table analyses. Because of differences in dates when young emerged from nests or burrows, numbers of juveniles captured were highly variable among species and years. In general, emergence of juveniles occurred in late July or early August, near the end of or following the period in which trapping was concluded. Therefore, yearly estimates of density for each species were the number

of different adults captured during the sampling period. We believe that most adults were captured each year, but have no data on proportions. Some young of each species were captured and marked each year, providing information on survival of known age individuals. Dynamic-composite life tables were constructed, which indicate minimal survival.

Changes in numbers of adults of each species were subjected to cyclic testing by fitting data points to cosine functions of various periods by computer (Halberg et al. 1972). In addition, serial correlation analysis (Poole 1974) was performed with Biomedical Computer Program BMC3D (Dixon 1973). These methods of time series analysis were selected to determine whether regular oscillations occurred in densities of the populations.

Locations of every capture were plotted on maps showing habitat categorized into the following six types: mixed deciduous-coniferous forest, spruce-fir (*Picea* spp. — *Abies balsamea*) forest, deciduous forest, savannah, open grass, and edge between open grass and forest. Those types in which large numbers of captures occurred were considered subjectively to be the preferred habitat of the species in the study area.

Results

We caught 443 *S. tridecemlineatus*, 215 *S. franklinii*, 501 *T. striatus*, 187 *E. minimus*, and 446 *T. hudsonicus* adults during the 22 years (Figure 1). Populations of *S. franklinii* and *E. minimus* declined to zero in 1965 and 1973, respectively. *E. minimus* was present in forest habitat adjacent to the study area and *S. franklinii* was present in State Park campgrounds and picnic areas located within 1.5 km of the study area. Animals from these sites probably repopulated the study area.

Because *S. franklinii* numbers appeared to be cyclic on about a 10 year pattern, all populations were subjected to cycle analysis (Table 1). Significant levels of cycles were found for all species except *T. striatus* by the cosine method. The high r^2 value of 0.81 for *S. franklinii* is a strong indication that the population is cyclic. Intermediate values for *S. tridecemlineatus* and *T. hudsonicus* and low values for the two chipmunk species are inconclusive. Length of cycle was consistent between both methods of analysis. Highs and lows in density appeared to be somewhat in synchrony for the two ground squirrel species and for the two chipmunk species (Figure 1).

Average combined sex ratios were expressed as percent males for the five species and compared with ratios reported for other parts of their ranges (Table 2). Although year-to-year variation in sex ratios occurred, sample sizes were sometimes so small that annual differences often were meaningless. Therefore, following the analysis methods used by other workers (Table 2), data for each species were pooled for the entire period. The ratios we found for adults of all species except *E. minimus* were within the reported ranges of values. For juveniles, the proportion of males was nearly identical to reported values for *S. tridecemlineatus* and within 4% of reported values for *T. striatus* and *S. franklinii*. Males comprised 61% of the juvenile cohort of *T. hudsonicus* compared with 52% as reported from two studies. We have no explanation for the large deviations from an equal sex ratio in *E. minimus*, 35% males for adults and 70% males for juveniles. The values may be a result of small sample sizes.

Life tables for all five species were computed from the period 1954 to 1975, and the $\log_{10}$ of survivors (l_x) was plotted against age in years (Figure 2). Each species was divided into cohorts of males and females. In general, all species exhibited similar diagonal, type II curves indicative of age independent survival (Deevey 1947).

Mean length of life for males and females combined was 1.02 years for *S. tridecemlineatus*, 0.74 years for *S. franklinii*, 1.14 years for *T. striatus*, 0.66 years for *E. minimus* and 0.81 years for *T. hudsonicus*. In all species, females exhibited higher survival rates than males (Figure 2). Similar findings of higher survival of females, but little in the way of explanation or cause, were reported for *S. tridecemlineatus* by McCarley (1966) in Texas and Rongstad (1965) in Wisconsin; for *S. franklinii* by Murie (1973) in Alberta; for *T. striatus* by Tryon and Snyder (1973) in New England; and for Red Squirrels by Davis and Selander (1971) in Saskatchewan.

Life expectancy (e_x) for each sex was plotted against the yearly age classes for each species (Figure 3). Higher mortality for juveniles and old individuals, as indicated by the curves for *S. tridecemlineatus*, *T. striatus* and *T. hudsonicus*, was reported common in mammals by Caughley (1966). *E. minimus* and *S. franklinii* deviate from this pattern. Small sample sizes in these species may have resulted in the apparent differences between the sexes.

We realize that because of the dates of termination of trapping, juveniles are under-represented in our life table data. In addition, we do not know whether individuals which disappeared died or dispersed. Hence, our results indicate minimum values for survival.

Because trapping was done in all habitats on the study area, habitat use was evaluated in terms of the number of captures in each type. *S. tridecemlineatus* was trapped almost exclusively in open grass and was especially common on a mowed athletic field. *S. franklinii*, on the other hand, was not found as often in

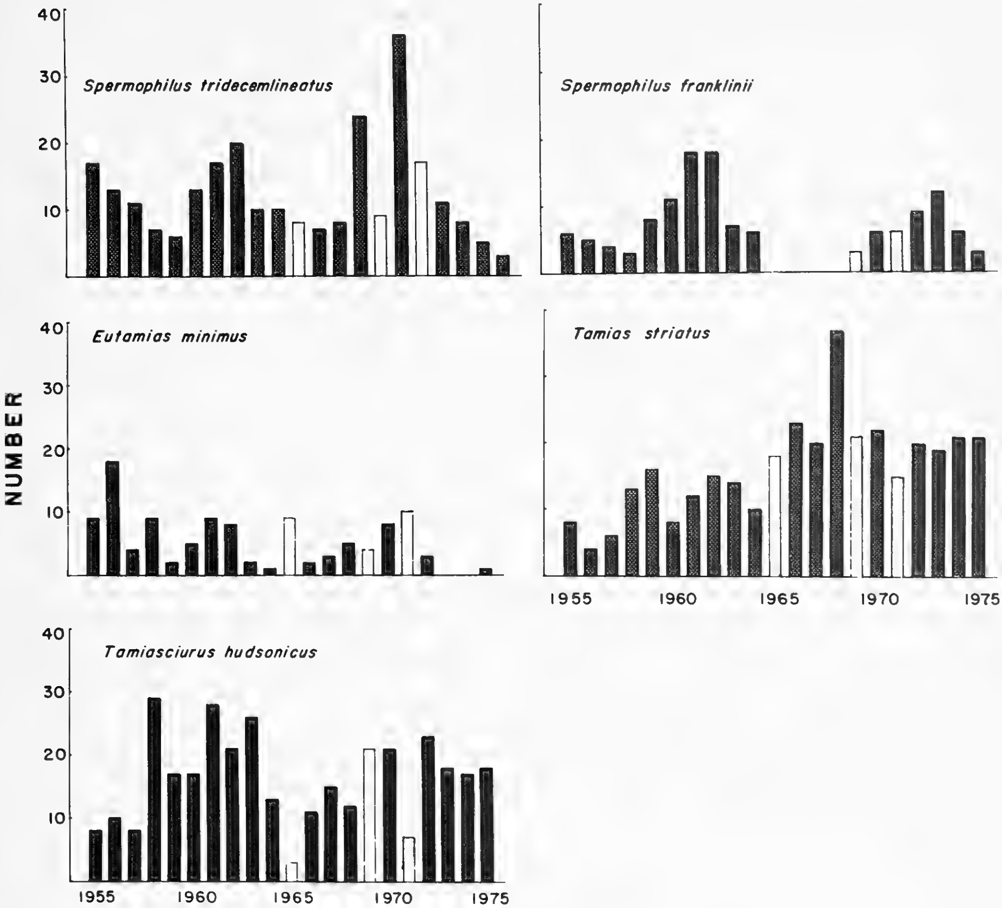

FIGURE 1. Number of adults of five species of Sciuridae trapped each year in northwestern Minnesota. Shaded bars represent captures from 10 June through 20 July and unshaded bars from 21 July through 31 August.

TABLE 1. Cycle analysis for five species of Sciuridae in northwestern Minnesota from cosine function and auto-correlation methods. Percent rhythm is the variability in the data accounted for by the cosine function. r^2 is the similar measure for the serial correlation method.

	Cosine analysis		Serial correlation	
Species	Cycle length in years	% Rhythm	Cycle length in years	r^2
Spermophilus tridecemlineatus	8	45	8	.46
Spermophilus franklinii	10	69	11	.81
Tamias striatus	8	21	9	.19
Eutamias minimus	7	32	5	.19
Tamiasciurus hudsonicus	11	53	11	.59

TABLE 2. Sex ratios of five species of Sciuridae in northwestern Minnesota expressed as percent males in the population. Figures in parentheses are sample sizes.

Species	% Males		Source
	Adult	Juvenile	
Spermophilus tridecemlineatus	35 (247)±±	51 (196)	This study
	31 (114)±±	52 (290)	McCarley 1966
	38 (60)	51 (172)	Rongstad 1965
Spermophilus franklinii	43 (129)	47 (87)	This study
	51 (47)	—	Iverson and Turner 1972
	41 (69)	50 (30)	Murie 1973
Tamias striatus	41 (294)±±	63 (207)±±	This study
	57 (1218)±±	52 (1500)	Tyron and Snyder 1973
	41 (56)	59 (22)	Pidduck and Falls 1973
Eutamias minimus	35 (93)±±	70 (94)±	This study
	58 (76)	—	Forbes 1966
	53 (195)	—	Sheppard 1968
Tamiasciurus hudsonicus	50 (324)	61 (122)±	This study
	52	52	Kemp and Keith 1970
	53	52	Davis and Sealander 1971

±significant at 95% level
±±significant at 99% level

the open grass areas but was captured along the edges where these areas met the forest. *Tamias striatus* was found mainly in forest habitat with shrubs such as *Corylus* spp. common in the understory. *Tamiasciurus hudsonicus* showed a strong affinity to areas containing fir and spruce. Both food and shelter are derived from these tree species, and several investigators (Kemp and Keith 1970; Rusch and Reeder 1978; Smith 1968) have shown the relationship between coniferous cone crops and squirrel numbers.

Discussion

Biological explanations of population cycles have been difficult and incomplete (Keith 1974; Krebs and Myers 1974). The problem consists of two parts. First, are real cycles present? And second, if so, what is the biological explanation for their existence? The Itasca data suggest that *S. franklinii* and perhaps some of the other species of sciurids may indeed have a periodic population cycle. Sowls (1948) noted four- to six-year cycles in *S. franklinii* at Delta, Manitoba and attributed such fluctuations to climatic extremes, infertility, and/or disease. Tryon and Snyder (1973) report the possibility of a three to four year cycle in *T. striatus*, but offer no explanation of the cause.

One possible explanation for the cyclic pattern is that *S. franklinii* in the Itasca area may be involved in the Snowshoe Hare – vegetation hypothesis outlined by Keith (1974). Predation on squirrels may be buffered by other prey species; however, when these are in low supply, the predators may turn toward *S. franklinii* or alternative food resources. Thus, these ground squirrels could be tied into the cycle and their numbers would show periodic but time-lagging declines and increases corresponding to those of the hares. Such a pattern is indicated if one compares the trapping data shown in Figure 1 to hare population data from Alberta (Keith and Windberg 1978) and to Ruffed Grouse (*Bonasa umbellus*) population data from Minnesota (Gullion 1970 and personal communication). For both hares and grouse, population peaks occurred in 1960-1961 and in 1970-1971 and lows in 1965-1966. The *S. franklinii* population peaked in 1961-1962 and in 1972-1973 and was at zero from 1965 through 1968. This time lag fits Kieth's (1974) model very well. While the other sciurid species also might be influenced by the same phenomenon, changes in their numbers did not reveal such a pattern.

Efforts were made to relate changes in numbers of adults to 15 climatic variables obtained from various sources using multiple regression techniques. This analysis did not identify key factors that could explain the population fluctuations of these species (Erlien 1977). Differences in significance of the various factors among species and between sexes was troubling. One would assume that some factor or set of factors would have broad influence on this taxonomic group. Perhaps the lesson to be learned here is that attempting to correlate climatic data obtained independently of the population study is not likely to be productive.

Before any biological significance can be attached to the survival for each sex (Figure 3), several points

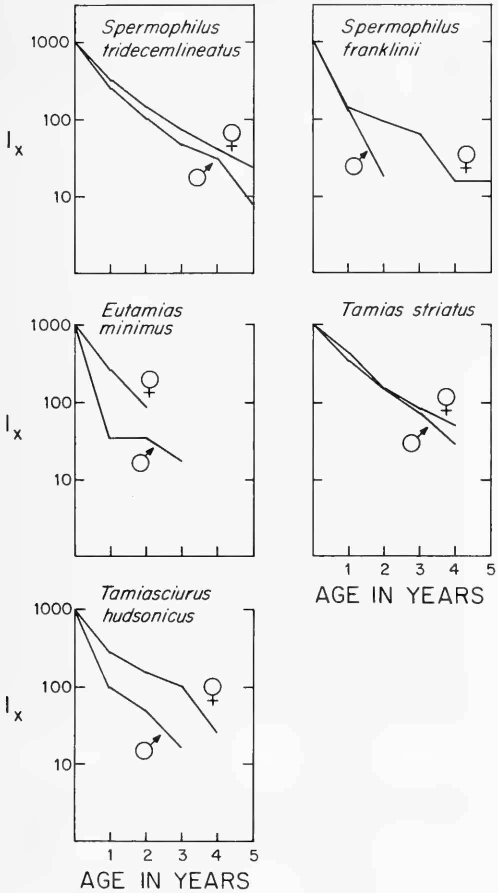

FIGURE 2. Survival curves for five species of Sciuridae in northwestern Minnesota. Starting bases of 1000 animals were calculated from cumulative cohorts of males and females from 1954–1970.

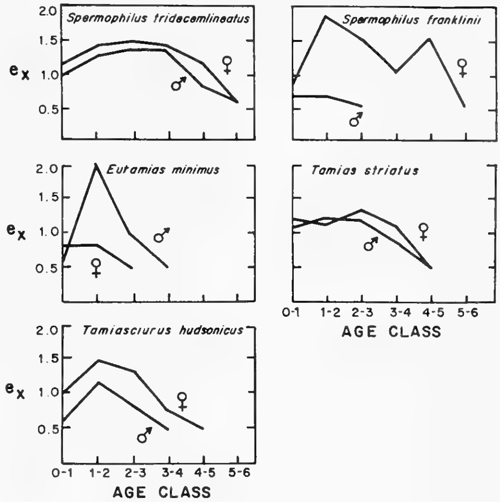

FIGURE 3. Life expectancy (e_x) of each yearly age class of five species of Sciuridae in northwestern Minnesota.

must be emphasized. First, the data were analyzed to indicate minimal survival (that is, disappearance due to death or emigration); this probably makes the survival curves conservative. Second, animals sampled were most likely not all residents of the Itasca Station area with established home ranges. "Drifters" or "floaters" would also tend to make the survival curves conservative. Despite these factors, our curves appear similar to those generated for these same species from other studies (McCarley 1966; Davis and Sealander 1971; Tyron and Snyder 1973; and Murie 1973).

Life expectancy comparisons (Figure 3) demonstrate different e_x values for females and males. For *S. tridecemlineatus*, *T. striatus*, and *T. hudsonicus* life expectancy is short for juveniles and old individuals, and females have greater life expectancies than males. Data for *S. franklinii* and *E. minimus* do not show these patterns, perhaps because of the small sample sizes.

Coexistence of the five species of sciurids at the Itasca Station is probably due to the variety of habitats available. Divergence and niche specialization in this group of Sciuridae may be reflected in the average weights of the five species, in differential food utilization, and/or in habitat preference.

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Comparison of Killdeers, *Charadrius vociferus*, Breeding in Mainland and Peninsular Sites in Southern Ontario

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Habitat characteristics, nest initiation dates, hatching success and egg size are described and compared for Killdeers (*Charadrius vociferus*) nesting on Long Point, Ontario, and the nearby mainland. Killdeers on Long Point began nesting later, and had smaller clutch volumes, lower egg weights, and lower hatching success. Egg size of Killdeers in both habitats did not vary systematically with laying sequence. Breeding density on Long Point was higher during the second nesting attempt (early June) than during the first attempt (late April), but lower than that reported elsewhere.

Key Words: Killdeer, *Charadrius vociferus*, nesting, egg size, breeding density, Long Point.

There are numerous published accounts of aspects of the breeding biology of the Killdeer, *Charadrius vociferus* (Davis 1943; Nickell 1943; Bunni 1959; Kushlan and Fisk 1972; Mace 1978; Lenington and Mace 1975). Those accounts referred primarily to Killdeers nesting in man-made habitats such as parking lots, lawns, gardens, etc., where the habitat was discontinuous and fragmented. The breeding biology of Killdeers living in those habitats may be altered from that of birds living in undisturbed habitats. We studied Killdeers nesting on the undisturbed sandy beaches and marsh edges of Long Point, Ontario, and birds nesting on the nearby mainland in typically disturbed sites. The Long Point peninsula juts into Lake Erie and hence is affected by low spring temperatures. That climatic difference may also affect the breeding biology of Killdeers there. We report and describe differences in nest initiation dates, incubation and laying periods, and egg size of Killdeers breeding on Long Point and on the nearby mainland.

Study Areas and Methods

The study areas were 1) wide pebbled beaches and the base of wooded ridges, bordered on the south by Lake Erie and on the north by *Typha* sp. marshes, on the western third of Long Point, Ontario (42° 34′N, 80° 17′W) (Figure 1), and 2) fields, old building foundations, cemeteries, parking lots and lawns around and up to 6 km from Port Rowan, Ontario, including five nests in the village of Long Point and one nest on the Long Point causeway, (42° 37′N, 80° 27′W) (Figure 1). The study was done in the springs and summers of 1977 (Port Rowan), 1978 (Long Point and Port Rowan) and 1979 (Long Point).

Nests on Long Point were arranged linearly along a stretch of beach measuring 7.75 by 0.15 km. No Killdeers nested on the narrow beaches to the east of the study area. Some nest territories were contiguous whereas others were separated by cottonwood (*Populus deltoides*) groves or water cutting through the sandy beaches. We calculated density on Long Point as the number of pairs divided by the total area minus those areas containing trees or water.

Nests on both study areas were located by first finding pairs of Killdeers, then searching potential nest sites thoroughly. On Long Point pairs were located on foot. On the mainland pairs were located by car. In both areas search effort was about equal; about 3 to 5 h/day during the laying period.

We measured 1) the distance to the nearest marsh, 2) distance to the lake, 3) the height above Lake Erie, and 4) the size of the nest clearing. The latter was defined as the area free of vegetation greater than 20 cm high. The Long Point study area was long and narrow and most nest clearings were approximately rectangular so we measured only the east-west and north-south dimensions. On large open beaches with more than one nest, the size of the nest clearing for all nests was the distance from one wooded ridge (or water) to the next, times the distance from Lake Erie to the marsh. On the mainland nest clearings were also approximately rectangular and they were measured as length times breadth.

Temperatures were obtained from a Stevenson screen at the study area (from 24 April to 22 July 1978), and from Environment Canada weather stations at the tip of Long Point and the mainland near St. Williams, Ontario, 3.5 km from Lake Erie shoreline (from 1 April to 31 July 1978).

Nests on Long Point were checked every other day

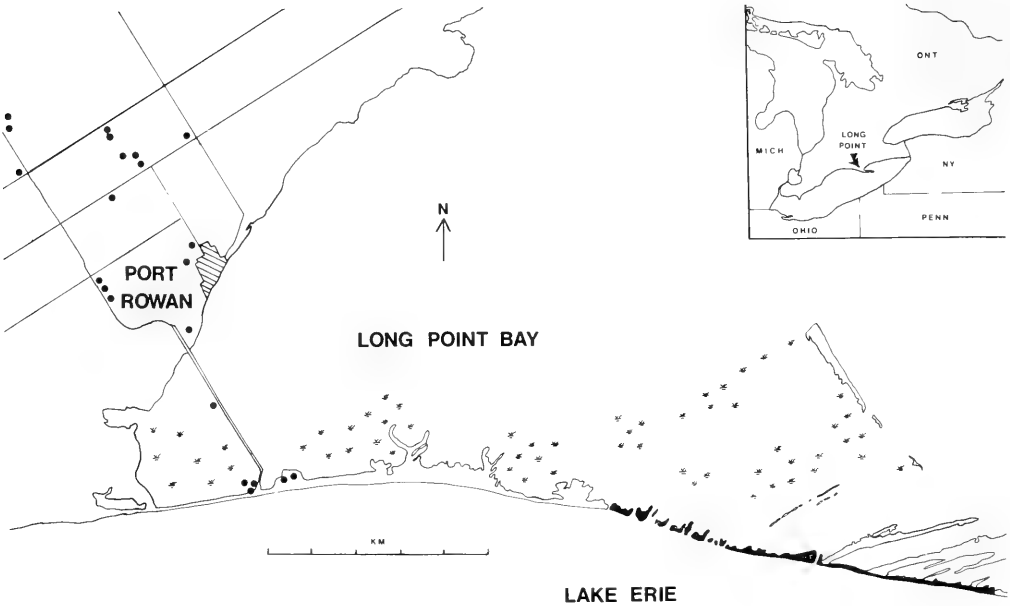

FIGURE 1. Map showing the Long Point study area (in solid black) and the nest sites near Port Rowan, Ontario (black circles). Inset shows Long Point in relation to Ontario, Michigan, Ohio and New York.

during incubation and every day during laying and hatching. Nests on the mainland were checked every day one week before and during laying (and hatching for two nests) but less often during incubation. Killdeers began incubating only after clutch completion, and we define the incubation period as the number of days from laying of the last egg to hatching of the last egg.

When found, eggs were marked with indelible felt-tip markers and measured with dial calipers to the nearest 0.1 mm. The eggs were weighed with a Pesola spring balance to the nearest 0.1 g. Not all eggs were weighed when fresh so we use volume measures for most comparisons.

Thirty eggs from museum collections were filled with water to find their volumes. Regression coefficients were calculated with volume as the dependent variable and the product of egg length (EL) x egg breadth^2 (EB) as the independent variable (Vaisanen et al. 1972). The resultant formula was used to calculate volume for all eggs measured: Volume = 0.4217 EL x EB^2 + 0.8875 ($r^2 = 0.94$, $p < 0.0001$). Shape was determined using the formula: Shape = (EL/EB) x 100 (Vaisanen et al. 1972).

We caught and banded 25 adults (12 in 1977, 13 in 1978), using walk-in nest traps, and monofilament nooses. We weighed and measured but did not sex the birds.

Results

In 1978 we measured habitat parameters for 33 nests on Long Point and 10 nests on the mainland. Nests on Long Point averaged 55 m from the lake, 50 m from the marsh, and 0.59 m above water level. The mean size of the nest clearing was the same for nests at both areas ($\bar{x}$ = 1.55 ha).

On the mainland, we found 10 nests in 1977 and 13 in 1978 (Figure 1). On Long Point we located 37 nests in 1978 and 16 in 1979. All the banded birds on Long Point but one (n = 12) were seen with replacement clutches (following loss of first clutches; nine pairs) or second clutches (after successful first clutches; three pairs) in the same areas as their first clutches, as was also found by Bunni (1959). On Long Point in 1978 we found what appeared to be first and replacement or second clutches for all pairs. However, seven new pairs moved onto the study area and laid only a late clutch. In 1978 on Long Point 15 pairs of Killdeers laid first clutches on 116 ha (12.9 pr/100 ha). Twenty-two pairs had clutches on the same area in the late nesting period (18.9 pr/100 ha). Those birds with young used these areas exclusively for feeding and

shelter for flightless young. We have no meaningful density estimates for the mainland because individual nests were separated by roads, houses, fields and wooded tracts (Figure 1). Killdeers breeding in Minnesota on open fields and asphalt areas had average densities of about 30 pairs/100 ha (estimated from three 24 to 43 ha sites; Mace 1978). In planted fields Mace found a density of 14.3 pairs/100 ha. There are no other density estimates for this species.

All nests contained four eggs at clutch completion. However, one pair lost their first egg and the female laid four more eggs in a new nest. The last egg laid was very pale in colour in comparison with the other four. Eighteen of 80 nests were found during egg-laying, and the remainder after completion of the clutch. Dates of nest initiation for the latter nests were estimated when possible by back-dating from hatching (using an incubation period of 26 days, Bunni 1959). The Killdeers on Long Point laid first eggs an average of 15 days later than those nesting on the mainland (28 April ± 8 days, N = 13, vs. 13 April ± 3 days, N = 8, $t = 4.95$, $p < 0.001$). Dates of clutch initiation were similar in both years for both study areas.

First clutches on Long Point for which laying and hatching dates were known appeared to have longer incubation periods than either first clutches on the mainland, second clutches on Long Point, or incubation periods reported in the literature (Table 1) although the sample size was small (n.s.). The laying period on Long Point also appeared prolonged ($\bar{x}$ = 6d 11h, n = 4, for Long Point; $\bar{x}$ = 4d 13h, n = 2 for mainland; n.s.).

Egg size did not vary systematically with laying order in 12 clutches (combining data from both locations; Table 2). Egg four (the last laid) was narrower, and had a significantly different shape than eggs 2 and 3. In breadth and shape it was not distinguishable from egg 1.

Egg weight was a good predictor of egg volume: Volume = 0.64 weight + 3.027, $R^2 = 61.1\%$, N = 42, $p < 0.0001$. We used this equation to predict the volume for four mainland nests for which we had weight measurements only. Total clutch volume for nests on the mainland was significantly larger than total clutch volume for nests on Long Point ($\bar{x} \pm$ S.D.; 50.78 ± 1.97 cc, n = 15, vs. 47.22 ± 2.18 cc, n = 26, $t = 2.62$, $p < 0.02$). Average egg weight was also significantly greater for nests on the mainland ($\bar{x} \pm$ S.D.; 14.74 ± 0.91 g, n = 31, vs. 14.00 ± 1.39 g, n = 22, $t = 2.34$, $p < 0.025$). Average clutch volume for six clutches from other mainland sites (Toronto to Barrie, Ontario, Royal Ontario Museum egg collection) was 53.1 ± 2.35 cc.

We calculated hatching success using a modified version of the Mayfield (1975) method for all nests found in 1978 (Table 3). Nests on the mainland had a slightly higher hatching success than nests on Long Point. On the mainland dogs were responsible for most nest losses, although in 1977 we also found nests plowed over by bulldozer tractors or shredded by lawn mowers. On Long Point, nests were most often destroyed by gulls (*Larus* sp.) and raccoons (*Procyon lotor*) (Nol and Brooks 1982).

Spring maximum temperatures at the tip of Long Point averaged 5.5° C lower in the month of April than comparable temperatures on the mainland (6.8° C vs. 12.2° C, $t = 3.69$, n = 30, $p < 0.001$). Maximum day and night temperatures at the study area during the laying period 25 April – 5 May 1978 were an average of 2.3° C higher than those at the tip of Long Point (10.1° C vs. 7.8° C; $t = 0.96$, n = 22, n.s.) and 2.6° C lower than temperatures on the mainland (12.7° C, $t = 0.99$, n = 22, n.s.).

TABLE 1. Incubation periods for Killdeer nests from five locations.

Location (Source)	First or second clutch	Mean date of clutch completion	Number of nests	Incubation period, days $\bar{x}$ + s.d.
Long Point (this study)	1	1 May	3	30.3 ± 1.5
Long Point (this study)	2	12 June	2	25.0 ± 0
Mainland (this study)	1	16 April	2	26.0 ± 0
Bloomfield Hills, Michigan (Nickell 1943)	1	13 April	2	26.0 ± 0
Ann Arbor, Michigan (Bunni 1959)	1	24 April	4	25.1 ± 0.25
Ann Arbor, Michigan (Bunni 1959)	2	18 June	2	24.3 ± 0.25
Minneapolis, Minnesota (Mace 1971)	1	24 April	1	25.0 ± 0
Minneapolis, Minnesota (Mace 1971)	2	28 May	5	25.0 ± 0

TABLE 2. Egg dimensions from 12 Killdeer clutches on Long Point and the nearby mainland, Haldimand-Norfolk R. M. Ontario. All values $\bar{x} \pm$ S.D.. Variation attributable to female or egg indicated with ANOVA.

	Egg 1	Egg 2	Egg 3	Egg 4	Total	Variation between Females P<	Eggs P<
Length, mm	38.1 ± 1.3	38.0 ± 1.4	38.1 ± 1.1	38.7 ± 1.2	38.2 ± 1.2	0.008	0.336
Breadth, mm	27.0 ± 0.7	27.1 ± 0.7[a]	27.3 ± 0.6[a]	26.8 ± 0.5[b]	27.1 ± 0.6	0.000	0.002
Shape	140.9 ± 5.4	140.1 ± 4.7[a]	139.2 ± 4.1[a]	144.1 ± 3.5[b]	141.1 ± 4.6	0.043	0.019
Volume, cc	11.8 ± 0.7	11.8 ± 0.9	12.0 ± 0.8	11.8 ± 0.7	11.8 ± 0.8	0.000	0.436

[a,b] Values marked 'a' differ significantly from values marked 'b'. $P < 0.05$, Duncan's Multiple Range Test.

Discussion

In this study we found one group of Killdeers initiating egg laying more than two weeks earlier than a second group at a nearby location. The clutches on Long Point were initiated later than clutches at two inland sites in southern Michigan (Bunni 1959, mean of four nests, 16 April; Nickell 1943, mean of three nests, 6 April) and later than at least some nests in Halton Regional Municipality, Ontario (as early as 4 April, M. Wernaart, personal communication) but at about the same time as nests in Minneapolis, Minnesota (Mace 1971, mean of 11 nests, 21 April). Lower temperatures on Long Point, leading to later emergence of insects, may have caused food to be less available early in the season and delayed egg production. Tree Swallows (*Tachycineta bicolor*) nesting on Long Point begin egg-laying later than their mainland counterparts, and that has been attributed to the later emergence of aerial insects on Long Point (D. Hussell, Ontario Ministry of Natural Resources, personal communication). In the northeastern United States Killdeers did not start laying until 13 days after the ground thawed and worms were easily available (W. Drury, personal communication *in* Perrins 1970). If, before deforestation in Ontario, Killdeers nested predominantly along lake shores, where spring temperatures are typically lower and emergence of available prey later than inland sites, then Killdeers breeding inland in recent times have benefited in their timing of breeding. Early breeding leaves more time for raising a second brood or laying replacement clutches. Killdeers in the southern United States have enough time to lay three replacement clutches after initial nest failure (B. Schardien, University of Mississippi, personal communication). Starting a clutch early also allows more time for chicks to develop flight capabilities and fat reserves for migration.

TABLE 3. Comparison of number of nests lost on Long Point and on the mainland near Port Rowan, Ontario, in 1978.

	Long Point	Mainland
Total nest days	262	238
Total number of nests observed	19	12
Actual number of nests lost	13	5
Calculated number of nests lost[1]	13.9	5.1
Expected number of nests lost[1]	11.7	7.4

[1]Calculated number of nests lost is based on Mayfield's (1975) average mortality rate for each locality. Expected number of nests lost is based on a common average mortality rate for each locality. Mainland nests lost were significantly fewer than nests on Long Point; $X^2 = 2.43$, $p < 0.05$.

Smaller clutch volumes, lighter egg weights, and possibly longer incubation periods on Long Point could suggest less food as well as later emergence of food there. Prolonged incubation may have resulted from eggs being cooled as adults interrupted incubation to feed. Similarly variable egg size between two nesting habitats of the Lapwing (*Vanellus vanellus*) was found to be related to differences in availability of earthworms at the two sites (Murton and Westwood 1974).

Killdeer egg size did not vary with laying order. Norton (1973) suggested that four similar-sized and shaped pyriform eggs form the optimal configuration in minimizing heat loss when uncovered. Although we found the Killdeer's fourth egg to be slightly wider than eggs 2 and 3, it is doubtful that those minor differences in shape affect heat loss. Little intra-clutch variation in egg size in this study is consistent with findings for other shorebirds (Wilcox 1959; Miller 1979; Vaisanen et al. 1972).

Minimization of heat loss may not be the only advantage of uniform egg size in shorebirds laying four eggs. Killdeers nest in many climates where the eggs can be uncovered for brief periods without danger of exposure. Killdeer young are fully precocial and hatching of all four eggs occurs on the same day (personal observation). Laying four eggs of uniform size may be the best strategy to ensure that all chicks have equal probability of survival at hatching.

The Killdeer is expanding its range in North America (Finch 1969; Strauch 1971; Kushlan and Fisk 1972). Killdeer on the disturbed mainland in this study appeared to have greater hatching success than birds

breeding in the undisturbed habitat of Long Point, at least in 1978. If that trend is consistent over many years, it may be that the range expansion of the Killdeer is in part attributable to their success in man-made habitats.

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Distribution and Habitat Use of Caribou, *Rangifer tarandus caribou,* and Moose, *Alces alces andersoni,* in the Spatsizi Plateau Wilderness Area, British Columbia

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A systematic aerial survey technique with calibrated transects to measure habitat preferences and movements of large mammals in remote areas of Canada is described. Four surveys were conducted in the Spatsizi Park, British Columbia, to monitor major movement patterns, distribution, and habitat preferences of Caribou and Moose. There was a major movement of Caribou toward the northwest in winter, so that most of them were wintering along the lower portion of the Stikine River Valley, whereas in spring, movements were toward the southeast portion of the park. Caribou showed no habitat preference in late winter, a preference for burns, brush, and spruce-pine forest in spring, and a preference for alpine areas in fall. Moose tended to be restricted to the major river valleys in winter and were more widely distributed in spring and fall. Moose showed a general preference for burns or brush in all periods, with some associated preference for spruce, spruce-pine, or pine forests. In both fall and late winter, Moose showed an avoidance of alpine habitat.

Key Words: Aerial survey, British Columbia, Caribou, *Rangifer tarandus caribou,* distribution, habitat selection, Moose, *Alces alces andersoni,* movement, Spatsizi.

The Spatsizi Plateau Wilderness Area in northern British Columbia contains one of the last major concentrations of Woodland Caribou, *Rangifer tarandus caribou,* (Banfield 1961) in the province. It is estimated that between 2000-2500 Caribou inhabit this and adjacent areas (Osmond-Jones et al. 1977). In British Columbia, this species has received relatively little attention. Edwards and Ritcey (1959, 1960) studied the Caribou in Wells Grey Provincial Park and Freddy (1979) has recently completed a study of the nearly extinct Selkirk Caribou herd on the British Columbia-Idaho border. However, in other regions, considerably more is known about Woodland Caribou ecology (Cringan 1957; Bergerud 1971, 1973, 1974; Stardom 1975; Shoesmith and Storey 1977). They appear to be behaviorally diverse, being primarily in the closed boreal forest (Shoesmith and Storey 1977), but showing periods of gregariousness in mountain regions (Bergerud 1973). Moose (*Alces alces andersoni*) also occur in the Spatsizi, as they do throughout the boreal forests of Canada (Banfield 1974). They are essentially solitary, though sometimes they gather in groups of 3-4 in winter.

The purpose of this paper is to describe the distribution, habitat use and major movement patterns of Caribou and Moose in the fall, later winter, and spring. A systematic aerial survey with calibrated transects has been used successfully for remote areas in Africa and Australia (Sinclair 1974, 1977; Pennycuick 1975; Norton-Griffiths 1975; Maddock 1979) and we considered it could be applied usefully in wilderness areas of Canada. This method is appropriate for Caribou in particular since knowledge of their distribution and movements is essential for their conservation.

Study Area and Methods

The Spatsizi Plateau Wilderness Park (Figure 1) was created in December 1975 by the British Columbia Provincial Government. It lies approximately 100 km north of Vancouver, B.C. and covers 6750 km^2, surrounding the Gladys Lake Ecological Reserve (33 km^2). The terrain is primarily mountainous, but the rugged relief in many areas of the park gives way to open alpine plateaus and wide glacier-shaped valleys. Many rivers and lakes are found throughout the area.

The climate of the Spatsizi is generally cloudy, moist, and cold (Pojar 1976). Winters are long and cold with mean monthly temperatures below freezing from October to April, and summers are cool and cloudy. At Cold Fish Lake, in the centre of the park but north of the main mountain range, mean monthly temperatures reach a high of +10° C in July (mean maximum 16.4° C) and a low of −20° C in January (mean minimum −24.7° C). Although Geist (1971) recorded 22 consecutive rain days in August 1962,

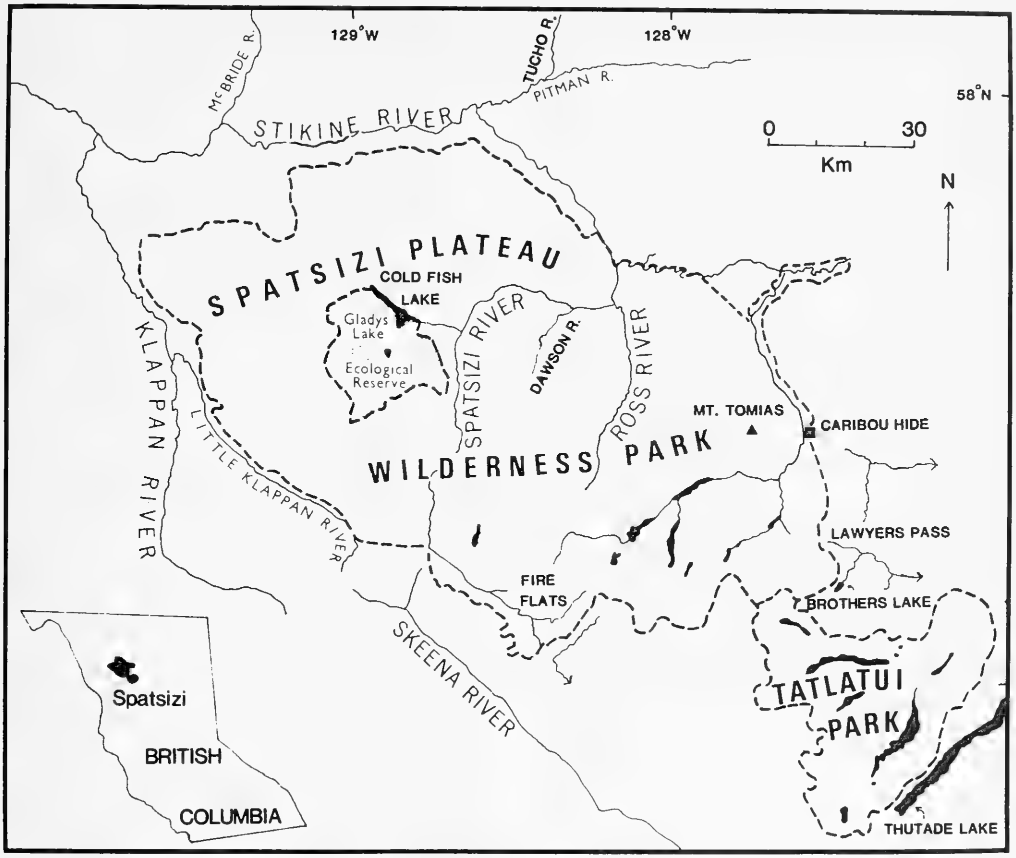

FIGURE 1. The Spatsizi area in northern British Columbia (from Surveys and Mapping Branch, B.C. Lands Service, 1976 edition).

total precipitation is not high (550 mm) and it is spread fairly evenly through the year. The lowest precipitation occurs in March-June.

There is a gradient of temperature and precipitation in the area, with the warmest and driest parts being in the north and north-east along the lower Stikine and Spatsizi Rivers. The snow cover here is 30-50 cm in depth. In the higher mountain ranges to the southwest, precipitation is higher and snow cover is 150-200 cm. The southeast of the Spatsizi Park and Tatlatui Park are higher and therefore colder than the northwest of the study area.

We surveyed the region by systematic aerial reconnaissance using the methods described in Sinclair (1972), Pennycuick (1975), and Maddock (1979). Over the wide valleys and flat plateau regions, we flew parallel transects 5 km apart. In the narrow valleys, we flew along them but ensured that every block on the map was surveyed. After the initial survey of the whole area in February 1976, we excluded the steep, rugged alpine terrain of glaciers and vertical faces not suitable for Caribou and Moose. A Cessna 185 aircraft was used with pilot and navigator in front and two observers in the back. Each observer surveyed his side of the aircraft up to 1 km from the plane. We also counted all animals within a transect of approximately 150 km width that formed an inner sub-sample of the 1 km width. The 1 km transect was delimited by a mark on the aircraft struts and the 150 m inner transects had similar marks with strings attached. We calibrated the transects by the methods described in Sinclair (1972) and Norton-Griffiths (1978). The data

We used the most detailed contour maps available, these having a scale of 1:250 000. The entire Spatsizi map (sheet #104H, National Topographic Series, Department of National Defence, second edition, 1974), the southern portion of Cry Lake (sheet #104I), the western portion of Toodoggone River (sheet #94E), and the northern portion of McConnell Creek (sheet #94D) were divided into grid blocks. Each block was 5 km wide and identified by column and row coordinates. These were subdivisions of the map 10 × 10 km grid. Since our survey path was about 2 km wide, we covered 40% of the 5 km wide block.

Four aerial surveys were conducted over the Spatsizi area: 5-8 March 1976, 25-27 May 1976, 28-30 September 1976, and 1-3 March 1977. The number of kilometers flown on each survey was 2005, 1759, 2063, and 1800 km respectively. Most of the transects were concentrated in the park, but some flights were made to the north, east, and south of it to see if caribou were also using these areas. The observers recorded the grid co-ordinates, and the number of each species of ungulate seen, using tape recorders and the data were subsequently transcribed onto computer sheets.

To relate the distribution of Caribou and Moose to their habitats, the vegetation of each grid block in the park was obtained from forest cover maps (Resources Analysis Branch, Ministry of the Environment, British Columbia). Within each block, the percent cover of each vegetation type was classified according to a modified Domin Scale (Kershaw 1973). The scale used had the following classes:

Scale	Percent Cover of Block
10	100
9	>75
8	50 - 74
7	33 - 49
6	25 - 32
5	13 - 24
4	3 - 12
3	1 - 2
2	trace
1	none

The forest cover types on these maps were condensed to the classes outlined below. The proportion of the Spatsizi survey area covered by the various plant communities is shown in Figure 2. Our description of the vegetation in these communities is taken from Pojar (1976).

ALPINE: This cover type is the dominant one in the Spatsizi area. It includes all land above the timberline (approximately 1525 m) whether it is vegetated or not. The forest cover maps made no distinction between rock and vegetation for this class. Pojar (1976) describes the alpine zone as including: (a) heath dominated by White Mountain Heather (*Cassiope tetragona*), Mountain Avens (*Dryas intergrifolia*), Dwarf Willows (*Salix reticulata, S. polaris*), and bryophytes; (b) tundra with the same Dwarf Willows, grass (*Festuca altaica*), sedges (*Carex* spp.), and, most importantly for Caribou, lichens.

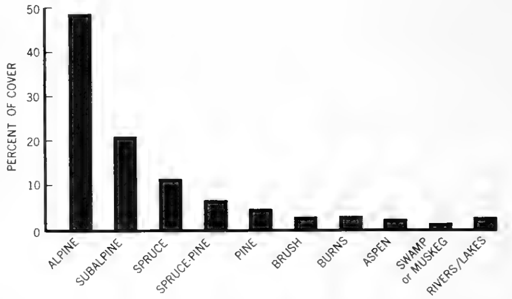

FIGURE 2. The frequency distribution of different plant communities and land forms in the Spatsizi area.

SUB-ALPINE FOREST: This is the second most abundant class and all cover types in which Sub-alpine Fir (*Abies lasiocarpa*) form a major component of the vegetation (>20% of gross volume indicated on the cover maps) are included. Sub-alpine Fir may be associated with White Spruce (*Picea glauca*), Lodgepole Pine (*Pinus contorta*), or any combination of these. In general, the *Abies* community occurs at higher elevations and forms the tree line. The closed canopy Sub-alpine Fir include feather moss, while more open areas support Dwarf Birch (*Betula glandulosa*) and Crowberry (*Empetrum nigrum*). Ground lichens are common.

SPRUCE: All cover types in which White Spruce forms a major component of the vegetation are included. Spruce may be associated with any one or combination of the following minor species (10-19% of gross volume on the cover maps): Sub-alpine Fir, Trembling Aspen (*Populus tremuloides*), Lodgepole Pine, Black Spruce (*Picea marina*). The few situations in which Black Spruce forms a major component of the cover are also included in this class because it is always associated with White Spruce as the other major component of the vegetation. Black Spruce accounts for only 0.82% of the entire study area.

Spruce forest is normally found on lower slopes and valley bottoms up to about 1400 m. The stands are open and associated with a well-developed shrub layer of Dward Birch and Grey Willow (*Salix glauca*). The ground level includes dwarf shrubs such as Crow-

berry, Soapberry (*Shepherdia canadensis*), Mountain Bilberry (*Vaccinium vitis-idaea*), and Labrador Tea (*Ledum groenlandicum*) and herbs such as *Lupinus arcticus, Epilobium angustifolium, Linnaea borealis* amongst others. Mosses and lichens are common, the species being similar to those in the Lodgepole Pine cover type.

SPRUCE/PINE: In this type, White Spruce and Lodgepole Pine form approximately equal components of the cover. The herb and shrub vegetation is similar to the spruce and pine cover types.

PINE: Lodgepole Pine forms the major component of the cover in this type, but can be associated with the following minor species: White Spruce, Black Spruce, or Trembling Aspen.

The frequent seedlings and saplings of White Spruce in this area indicate the seral nature of this pine community. The shrub layer is not well developed, although Dwarf Birch and Grey Willow are most abundant, and lichens, especially those eaten by Caribou: *Cladonia mitis, C. rangiferina,* and *C. alpestris*. Epiphytic lichens are also abundant.

BRUSH: In this type, few or no trees are found and the vegetation is dominated by Dwarf Birch and various willow species (*S. alaxensis, S. barclayi,* and *S. glauca*).

BURNS: In this area, regeneration of trees had not yet occurred to a significant extent after a fire. Shrubs were poorly developed but similar to spruce and pine types.

ASPEN: Trembling Aspen forms the major component in this type, but it is also associated with other cover types; e.g. White Spruce, Lodgepole Pine or Balsam Poplar (*Populus balsamifera*). Aspen communities are common on drier sites along the major valleys, especially on southfacing slopes of the Spatsizi, Stikine, and Klappan Rivers. Some dense stands of stunted aspen (2-7 m height) reach 1500 m. The shrub layer includes *Salix scouleriana,* Soapberry, Prickly Rose (*Rosa acicularis*), and Bearberry (*Arctostaphylos uva-ursi*). Lichens and mosses are uncommon, as are epiphytes.

We also include in this type the few stands of Balsam Poplar. Poplars occupy moister sites than aspen and well-developed stands are found only in the northwest of the study area on flood plain terraces of the Stikine and lower Klappan rivers. The shrub stratum is sparse, but the herb layer is rich with broad-leaved forbs (e.g., *Delphinium glaucum, Lupinus arcticus*). Lichens are almost absent. Snow cover in both the Balsam Poplar and aspen stands is deeper than in the conifer cover types. Althugh neither the forest cover maps nor Pojar (1976) mention White Birch (*Betula papyrifera*), we noticed it throughout the area, particularly in the aspen types.

SWAMP AND MUSKEG: This type includes all boggy areas which support little or no tree cover.

RIVER/LAKES: The larger river systems associated with the Stikine River are found mainly in the north of our survey area. Lakes are most numerous in the southeast of the area (Figure 1).

In general, the most common cover type in the Spatsizi survey area is alpine plateau (49%) (Figure 2). Coniferous trees dominate the forest cover, with Subalpine Fir and White Spruce being the most common. Below timberline, there is relatively little open ground (not including rivers and lakes); areas with brush, burns, and swamps/muskeg account for only 6.5% of the total area.

To determine whether Caribou and Moose selected for specific vegetation classes, only grid blocks which were actually flown over in a particular survey were included in the analysis. Each of these blocks was classified according to the presence of a particular vegetation class in it and to the presence of Caribou or Moose. A vegetation class was regarded as present in a block if it covered at least 3% of the area. We measured the degree of association of either Caribou or Moose with a vegetation type by using Cole's (1949) coefficient of association following the technique reported in Sinclair (1977). Although Hurlbert's (1970) coefficient of association was calculated at the same time, we did not use it since both coefficients were very similar. Cole's coefficient ranged from +1 (maximum positive association) to -1 (maximum negative association), with zero indicating random association. The major shortcoming in our analysis resulted from the large size of the blocks we used. (We could not reduce the blocks because of the small scale of maps that were available to us.) Our blocks sometimes included many vegetation types, and were, therefore, more heterogeneous than we would have liked. The mountainous terrain, with the rapid changes in altitude, caused the vegetation to be heterogeneous over short distances. Nevertheless, we did find major patterns of association between the herbivores and vegetation classes.

Results

CARIBOU

Cole's coefficient of interspecific association between Caribou and the vegetation classes is shown in Figure 3 and their distribution over the park is shown in Figure 4. Because the swamp and muskeg class was rare and the rivers/lakes class ubiquitous but generally covering only a small portion of the area, neither were included on Figures 3 and 5. Both the March 1976 and 1977 surveys took place in late winter when temperatures fluctuated around -10°C. Snow cover was around 50 cm in depth in the conifer

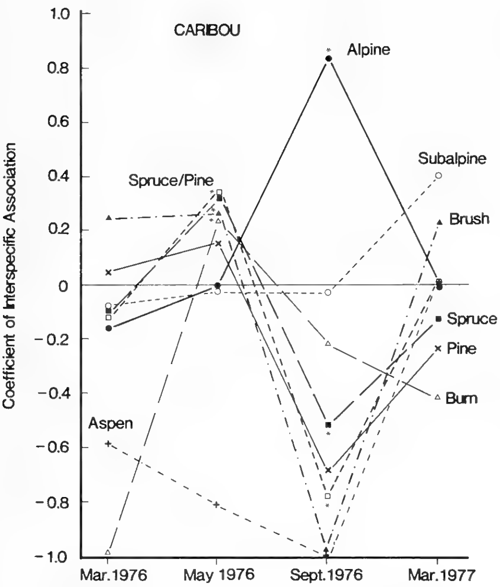

FIGURE 3. Cole's coefficient of association of Caribou with different forest cover types on the four aerial surveys. Asterisk indicates significant association at $P < 0.05$.

areas and Caribou were digging through it to the herb layer. In both winter surveys, none of the association coefficients were significant, indicating that Caribou were found throughout the vegetation types in proportion to their occurrence in the transects (Figure 3). In both years, Caribou wintered in the northern half of the park along the Stikine River, with the major concentration occurring along the northeastern edge of the Spatsizi Plateau. The largest Caribou herds (68 in 1976 and 208 in 1977) were seen in the sub-alpine zone on the same slope. In March 1976, flights were restricted to the main park area and the immediately adjacent land. In 1977, we extended the survey into the south of Tatlatui Park, but we saw no Caribou tracks. We also surveyed north of the Stikine River along the McBride, Turnagain (north of map), Tucho, and Pitman Rivers. Caribou tracks were numerous along the McBride and Turnagain Rivers, although we saw only three small groups of Caribou along the Turnagain River. Therefore, in March, Caribou showed no preference for any vegetation type, but they did concentrate their activities in the northern portion of the park.

In late May 1976, snow had melted from most of the area below the tree line in the north and centre of the study area; rain fell intermittently and temperatures were around +5°C. However, snow still covered the area south of Caribou Hide camp on the upper Stikine River, in the southeast of the study area. This area is higher and colder, and snow showers were frequent. Caribou were scattered in small groups throughout the north, centre, and east of the area (Figure 4), and, unlike the March surveys, no large groups were seen. They were moving south in lines through Lawyers Pass at the edge of the snow. It appeared they were following the snow melt southwards. Under these conditions, Caribou showed a significant preference for brush ($P < 0.005$), burns ($P < 0.005$), and spruce-pine stands ($P < 0.025$) only (Figure 3).

In late September 1976, winter was approaching and snow showers were occurring in the alpine areas, although it was still raining below the tree line. Caribou showed a significant preference for the alpine zone ($P < 0.05$) and a significant avoidance of spruce ($P < 0.01$), and spruce-pine ($P < 0.01$) forests (Figure 3). The largest concentrations were seen on the Spatsizi Plateau above Cold Fish Lake (70), in the alpine and sub-alpine zones of Mt. Tomias (herds of 150 and 240), and in the alpine zone north of Brothers Lake (52). Smaller herds (43, 38, 32) were also seen in the alpine zone east of Lawyers Pass. The survey extended north of the Stikine following the Pitman and Tucho Rivers, but no Caribou were seen. We surveyed Tatlatui Park and south of it to Thutade Lake: six Caribou were sighted in the alpine zone just south of Thutade Lake. Therefore, at this time of year, Caribou were primarily concentrated in the alpine zones in the large herds, the height of the rut occurring around 10 October. We estimated this date by back extrapolation from the sighting of the first calf in late May.

MOOSE

Moose showed no significant preference for any vegetation type in March 1976, although their preference for spruce-pine forests and burns approached significance ($P < 0.10$) (Figure 5). Many of the Moose were associated with valley bottoms and the largest concentrations were seen on the lower Spatsizi River. In March 1977, there was a significant avoidance of alpine areas ($P < 0.025$) and a significant preference for pine forests ($P < 0.025$) and for brush ($P < 0.001$) with spruce and spruce-pine forests approaching significance. The two largest concentrations were seen on the upper Ross River and on the Dawson River, both locations where they were not seen in 1976 (Figure 4). In contrast, relatively few were found on the lower Spatsizi. No Moose were seen on the flight into Tatlatui Park and south to the Skeena River. In the flight north of the Stikine (see Caribou section), only two Moose were seen, again on the Turnagain River.

In May 1976, Moose showed a significant preference for spruce forests ($P < 0.05$) and the preference

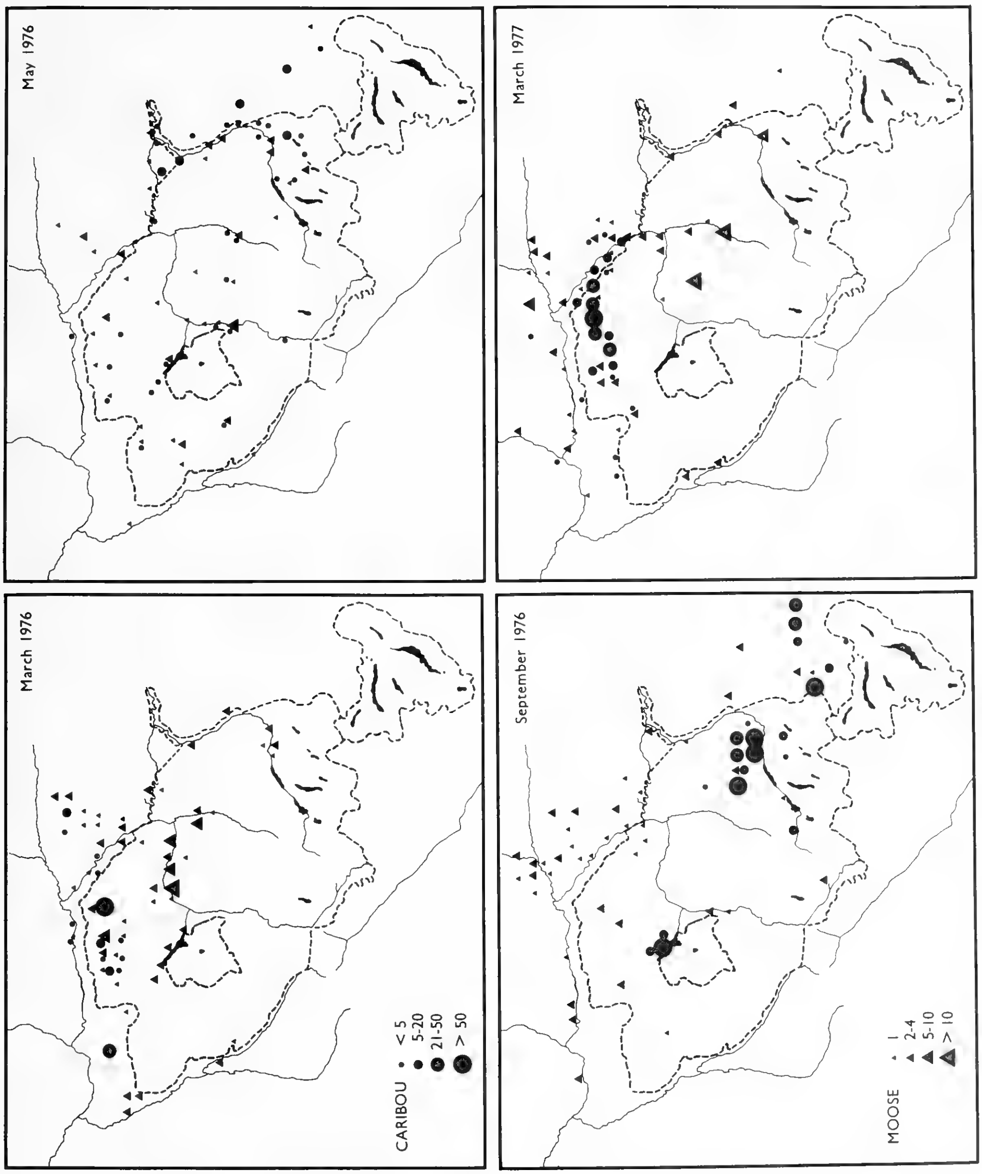

FIGURE 4. The distribution and abundance of Caribou (●) and Moose (▲) in the Spatsizi area during four aerial surveys.

for burns approached significance ($P < 0.10$) (Figure 5). They were widely distributed throughout the area with no large concentrations seen anywhere and only one moderately large concentration seen on the Spatsizi River. No Moose were seen in Tatlatui Park during our survey.

In September 1976, there was a significant avoidance of alpine areas ($P < 0.01$) and a significant preference for brush ($P < 0.025$) (Figure 5). They were widely distributed with no major concentrations seen anywhere (Figure 4).

Discussion

This type of survey technique has a number of inherent biases, a major one being the visibility of the ungulates (Caughley 1974; W. C. Gasaway personal communication). LeResche and Rausch (1974) found that even under ideal conditions, experienced observers were able to see only 68% of the Moose present. Novak and Gardner (1975) estimated 90% visibility of Moose in aerial transects over forests in Ontario. All of our surveys were conducted with people who had ground experience with the various ungulates and most had experience with aerial surveys as well. In addition, all surveys were conducted when leaves were absent from deciduous trees. Nevertheless, estimates of Caribou and Moose in the coniferous stands are probably too low. However, we believe that the broad picture is correct.

The Caribou population in the Spatsizi area under went seasonal shifts over the four time periods examined in our study. In late winter (the March surveys), they were concentrated in the northern half of the park with the largest concentrations occurring in the sub-alpine zone. But Caribou did not use this zone exclusively; all other vegetation types were occupied in proportion to their presence on the area. More frequent surveys during the winter may show up significant habitat preferences at other times in the winter. At present our results indicate that Caribou have no strong preference for any particular habitat in late winter.

In contrast to our results, both Edwards and Ritcey (1959) in Wells Grey Provincial Park, and Freddy (1979) in southern British Columbia and northern Idaho, found the Caribou exclusively occupying sub-alpine spruce-fir forest, eating primarily arboreal lichens, *Alectoria* spp. (Edwards and Ritcey 1960). Bergerud (1974) found that Newfoundland Caribou, which also tended to occupy mountainous habitat, chose a variety of habitats, depending on snow cover conditions. During winters of thick snow cover, they sought high, exposed, wind-swept ridges. At other times, sub-alpine areas with few trees and exposed lichen woodland provided the best habitat. Their diet consisted primarily of arboreal lichens and evergreen shrubs. In the low altitude study in Manitoba, Stardom (1975) described Caribou feeding on arboreal lichens in tamarack (*Larix laricina*) bogs in early winter under windless thin snow cover conditions. Once a snow crust had developed from windy conditions, the Caribou moved to Jackpine (*Pinus banksiana*) rock ridges where they fed on ground lichens. These ground lichens were more important than tree lichens as winter food in Manitoba, because hard and deep snow inhibited use of the main tree lichen areas for 60% of the snow season (Stardom 1975). This main conclusion that nival conditions dictated where and on what Caribou fed, suggests that the Caribou in our study may have been forced out of the southern end of the park because it was higher in elevation and had thicker snow cover.

The late May survey took place just prior to the calving period. One cow with calf was actually sighted in a Dwarf Birch — willow meadow. The significant selection of burns and brush vegetation suggests that they were looking for more open habitats, perhaps in which to calve. In the Gladys Lake Ecological Reserve region of Spatsizi, Geist (1971) noted that Caribou cows gave birth on the highest mountain ridges, again suggesting their need to seek secluded sites perhaps less vulnerable to predators and insect attack. All the cows monitored during the study of Shoesmith and Storey (1977) calved on islands where predators were less abundant. However, cows did not seek secluded sites in the study of Bergerud (1974), where no wolves occur, nor in the studies on the barren land Caribou by Lent (1966) and Kelsall (1968), where wolves do occur.

In the fall, Caribou showed a pronounced selection for the alpine zone and an avoidance of spruce and spruce-pine forests. This coincided with the annual rut. Similar use of high exposed areas on mountains has been found by Bergerud (1973) on Mt. Albert, Quebec. In Newfoundland, Bergerud (1974) indicated that Caribou used open areas for the rut but did not specify where these open areas were. Bergerud (1973) suggested that alpine zones were used because they facilitated herd formation and allowed females to breed with the most dominant male.

Habitat selection by Moose in the Spatsizi was similar to that reported in other studies. In fall, Moose selected open habitats with brush in them, but avoided alpine areas. In winter and late spring, Moose selected burns and brush plus heavily forested habitats of spruce and pine, and in one case (March 1977), again showed a significant avoidance of alpine areas.

The importance of early seral stage plant communities to Moose populations has been well documented (Hatter 1950; Phillips et al. 1973; Krefting 1974; Irwin

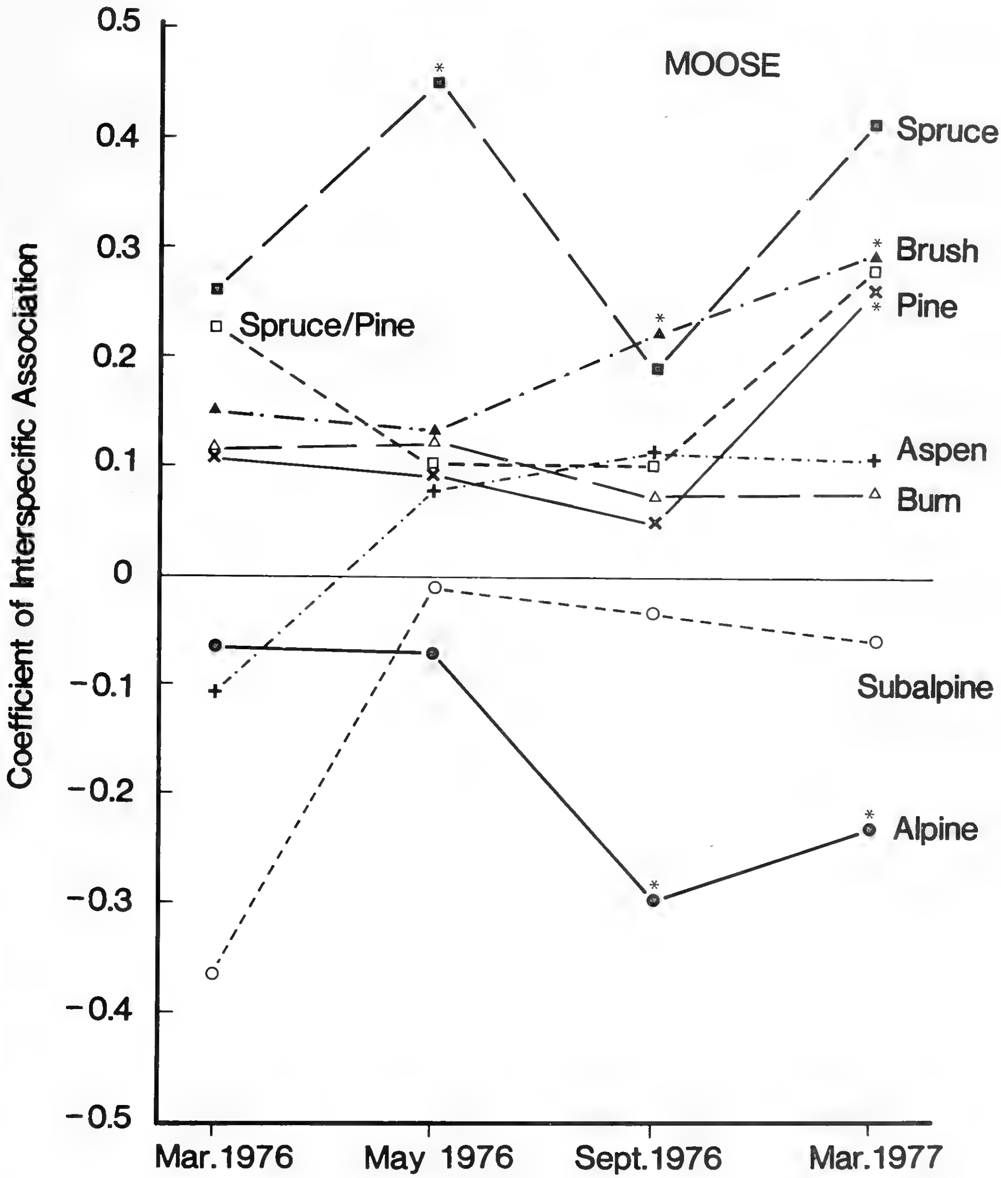

FIGURE 5. Cole's coefficient of association of Moose with different forest cover types on the four aerial surveys. Asterisk indicates significant association at $P < 0.05$.

1975; Peek et al. 1976), for they provide an abundance of browse species such as willow (*Salix* spp.). Logging can also result in an abundance of these browse species. Near Prince George in north-central B.C. (600 km southeast of our study), Eastman (1978) found that willows, Red-osier Dogwood (*Cornus stolonifera*), and grasses were the dominant foods in fall; willow, White Birch, and Red-osier Dogwood were dominant foods in early winter; and Sub-alpine Fir, willow, and White Birch were dominant foods in late winter. The shift in late winter to eating some conifers was due to a shift in habitat. Because of the thicker snow cover in late winter, Moose moved to heavily forested conifer areas at this time. The shift to coniferous forest in late winter has also been reported for other areas across North America (Edwards and Ritcey 1956; Telfer 1970; Kelsall and Prescott 1971; Krefting 1974; Peek et al. 1974; Rolley and Keith 1980).

The selection for both open and forested habitat in late winter and spring in our study suggests that vegetation diversity may be an important variable. In Alaska, LeResche et al. (1974) found that high vegetation heterogeneity characterized winter moose habitat. Eastman (1978) found that partially logged sites were preferred over all other sites. Similar findings have been reported by other workers (Prescott 1968; Peek et al. 1976). Moose in our study were usually found near rivers or streams in March and May (note that Figures 1 and 4 indicate only the larger rivers). These habitats provide high vegetation diversity because of river flooding, erosion, changes in stream channels, and ice damage (Peek 1974). Riparian habitat was also used extensively by Moose in Alaska (Mould 1979) and in Montana (Peek et al. 1974).

The technique described here for monitoring movements, distribution, and habitat preferences of large mammals, such as Caribou and Moose, in difficult or inaccessible terrain is efficient in time, manpower, and cost, compared to alternative ground studies. The four surveys demonstrated a migration of Caribou northwest for the winter (towards the warmest area with the thinnest snow cover) and southeast in the spring. Habitat preferences of both Caribou and Moose agreed with results from other areas. Caribou showed little habitat selection in our late winter surveys, perhaps because lichens and herbs on which they fed were abundant in all major habitats in the northern Spatsizi under the prevailing nival conditions.

Acknowledgments

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Seasonal and Diurnal Abundance of Aquatic Birds on the Drizzle Lake Reserve, Queen Charlotte Islands, British Columbia

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A 112 ha lake on the Argonaut Plain, Queen Charlotte Islands, was surveyed for abundance and movement of birds at weekly intervals from 1978 to 1982. Thirty-six species utilized the lake; species numbers were highest in April and May and total bird-days highest in October and November. The majority of individuals were non-breeding and used the lake for foraging or overnighting. Red-throated Loon, Common Loon, Canada Goose, Mallard and Common Merganser, which moved between nearby marine water and the lake on a daily basis, accounted for the greatest number of yearly bird-days. Estimates of yearly prey consumption by piscivores at the lake range from 0.25 to 0.49 g/m^2.

Key Words: aquatic birds, seasonal abundance, coastal bog lake, Ecological Reserve, Queen Charlotte Islands.

The Queen Charlotte Islands, 100 km off the coast of British Columbia, lie along a major migratory corridor and provide coastal wintering habitat for many aquatic birds (Bellrose 1980). Although estuaries and near-shore marine waters represent the principal habitats for those species, coastal lakes could be an important alternate habitat for migratory stops, shelter during oceanic storms or foraging. Major use by aquatic species would influence ecological factors such as nutrient levels and distribution and abundance of prey in lakes. Non-breeding Common Loons (*Gavia immer*), which make daily transits between ocean and lakes in this region (Reimchen and Douglas 1980), are suspected of exerting a significant evolutionary pressure on the morphology of freshwater Threespine Sticklebacks, *Gasterosteus aculeatus* (Reimchen 1980, 1983). To determine the extent to which aquatic birds (non-breeding seasonal residents and breeding pairs) use coastal lakes, we documented the numbers and movement of all birds associated with a lake over a period of five consecutive years. The survey is part of a study on biotic interactions between aquatic birds and freshwater fish and serves as baseline data for Drizzle Lake, an area protected under the Ecological Reserves Program of British Columbia as a benchmark for assessing long-term changes in ecosystems (Krajina et al. 1978).

Study Area and Methods

Drizzle Lake (53°56′N, 132°05′W) (112 ha) is located on the Argonaut Plain, an expanse of *Sphagnum* bog and coniferous forest in the northeast corner of Graham Island (Figure 1). The watershed was established as a Reserve in 1971 (Krajina et al. 1978) for its unusual population of Threespine Stickleback (Moodie and Reimchen 1973) and as a representative High Moor bog. Further habitat description was given by Reimchen and Douglas (1980).

For all aquatic bird species, records were maintained on number, distribution, arrivals and departures and general behaviour (foraging, preening, resting, etc.). Observations (15 min periods) were made with spotting scopes near dawn, mid-day and dusk at least one day per week for some 40 weeks per year from 1978 to 1982. As fog or storms occasionally limited visibility, especially in fall and winter, numbers of individuals may be underestimated for some species. For each month, we present maximum daily numbers observed, averaged over the number of years that a species was present. Total monthly and yearly "bird-days" (number of individuals X number of days present) were calculated for each species, based on weekly, or in some cases, daily records. As some species exhibited regular diurnal movement to and from the lake, we categorized each as day occupant, night occupant or continuous day and night, the latter applicable to species which arrived on the lake and remained continuously for two or more days. Foraging activity was described as absent, occasional (< 10 % of all sightings) or common (> 10 %).

Results

Summarized data for each species are given in Table 1. From 1978 to 1982, 36 species were observed on the lake: loons (3 spp.), grebes (4), cormorant (1), heron (1), swan (1), geese (2), ducks (15), shorebirds (4), gulls (2), murrelet (1), kingfisher (1) and dipper (1). Breeding was confirmed for Red-throated Loon, Canada Goose, Mallard, Green-winged Teal and Hooded Merganser, and suspected for Great Blue Heron and Marbled Murrelet (all scientific names given in Table 1).

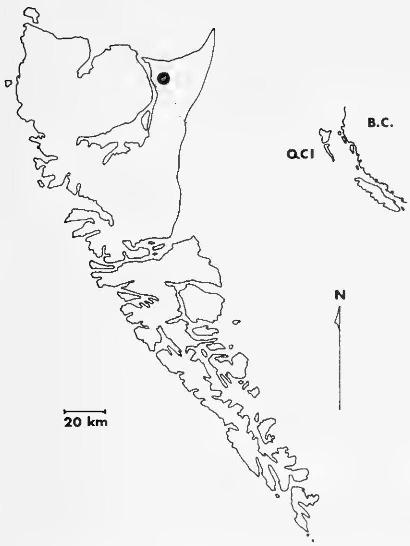

FIGURE 1. Queen Charlotte Islands showing Argonaut Plain (stippled) and Drizzle Lake Ecological Reserve (solid circle). Inset — British Columbia.

Most species exhibited a consistent seasonal occurrence and numerical abundance between years. Common Loons were at peak abundance in July, with maximum daily numbers ranging from 27 to 60 during the five years. In spring, approximately 30 (range between years, 15-75) male and female Common Mergansers occupied the lake daily; in fall, maximum numbers ranged from 85 to 124 between years, with the majority of birds in immature plumage. Mallards showed seasonal peaks similar to mergansers, with November maxima of 100-200 birds. From one to five Red-necked Grebes, Horned Grebes and Buffleheads were present from October to April of each year, with numbers increasing slightly in April, prior to their departure from the lake. The Double-crested Cormorant occurred between February and April, with only one to three individuals present at any time.

Canada Geese included breeding pairs, sub-adult congregations during molt, small resident flocks which moved irregularly between the lake or bog and the ocean, and migratory flocks. The latter (which are not included in total bird-day calculations) were frequent from mid-September to early November in south-east migration over the lake. On 2 October 1981, 22 flocks (40-270 birds/flock) were observed between 1200 and 1900 PST, with additional flocks heard throughout the night. Similar movements were observed on 12 October 1978, 12 October 1980 and 15 October 1982. Flocks in September and early October never stopped at the lake, but in three of the five years, several flocks in late October and early November landed and remained for several days. Resident geese did not join the migrants.

Species numbers were highest in April and lowest in December and January (Figure 2). Total numbers of individuals (bird-days) generally increased to a maximum in October, with minor peaks in April and July (Figure 2). The major contributors to those fluctuations were Mallard (7820 bird-days), Canada Goose (4858), Common Merganser (3553), Red-throated Loon (1884) and Common Loon (1626). Large flocks of Mallards and Common Mergansers accounted for the increase in bird-days during late fall.

There were regular diurnal movements between the lake and nearby marine waters. Red-throated Loons, Common Mergansers and Glaucous-winged Gulls were primarily night residents, arriving on the lake near dusk and departing again the following morning, mergansers usually at dawn and loons 1-3 h after sunrise. Common Loons and Mallards were principally day occupants; the former arrived near dawn, reaching peak abundance by mid-morning, whereas the latter species generally were present from mid-day to dusk. Other species, such as Double-crested Cormorant, Canada Goose, Scaup, White-winged Scoter and Belted Kingfisher also made daily transits between ocean and lake but at irregular times.

Among the 13 species that foraged regularly on the lake, 9 were piscivores. Where fish could be identified (for loons, grebes, mergansers and kingfisher), Threespine Stickleback was the only prey. Resident Green-winged Teals, Mallards and Buffleheads occurred primarily in shallow bays and are suspected of taking trichoptera larvae and vegetation. Canada Geese seldom foraged on the lake, but rather fed on shoreline vegetation and in adjacent bogs.

Species were assigned to one or more of three categories: migrants, which were present for $<$ 5 days per year during the major migrations, seasonal residents, both breeding and non-breeding, which remained on the lake for one week to three months, and daily itinerants, which travelled to and from the ocean on a daily basis. Summarized data (Table 2) showed that half of the species used the lake as a migratory stopover. Those species, which rarely foraged, accounted for only 1 % of the total yearly bird-days. The 12 species of resident birds contributed 20 % to the total bird-days. By far the greatest use of the aquatic habitat (79 %) was by itinerants, principally Red-throated Loon, Common Loon, Canada Goose, Mallard, Common Merganser and Glaucous-winged Gull. Of those, only the Common Loon and Canada Goose were regular foragers.

TABLE 1. Seasonal abundance and occurrence of aquatic birds on the Drizzle Lake Ecological Reserve, Queen Charlotte Islands, 1978 1982. Figures show, for each month, daily maximum counts averaged over number of years present and maximum observed per day (in brackets). TBD — total bird days; Y number of years present (Max. 5); Di — diurnal occupation by aquatic species, principally in daylight (D), principally twilight and darkness (N), full day and night occupancy (DN) and variable (V); F — foraging activity, not observed (0), occasional (1) and common (2). December data limited to 1979, showing maximum observed. No data (—). Nomenclature follows A.O.U. (1982).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TBD	Y	Di	F
1. Red-throated Loon	0	0	0.4	8.4	11.8	11.0	14.6	13.2	2.6	0	0	0	1 884	5	N	1
Gavia stellata			(1)	(12)	(15)	(16)	(19)	(20)	(5)							
2. Arctic Loon	0	0	0	0	0	1	1	0	0	0	0	0	30	1	DN	2
G. arctica																
3. Common Loon	0	0.2	0.2	0.6	1.0	14.0	43.4	12.8	1.2	1.8	0.8	0	1 626	5	D	2
G. immer		(1)	(1)	(1)	(3)	(24)	(60)	(24)	(3)	(5)	(2)					
4. Pied-billed Grebe	0	0	0	0	1	0	0	0	0	0	0	0	17	1	DN	2
Podilymbus podiceps																
5. Horned Grebe	0	0.2	0.2	0.6	0.2	0	0	0	0.4	1.2	0.2	0	91	5	DN	2
Podiceps auritus		(1)	(1)	(2)	(1)				(1)	(4)	(1)					
6. Red-necked Grebe	0.2	0.2	0.4	1.8	1.6	0	0.2	0.4	1.8	3.0	0.8	1	341	5	DN	2
P. grisegena	(1)	(1)	(1)	(8)	(7)		(1)	(1)	(2)	(4)	(2)					
7. Western Grebe *Aechmophorus occidentalis*	0	0	0	0	0	0	0	0	1	0	0	0	2	1	DN	1
8. Double-crested Cormorant	0	0.3	1.5	1.0	0	0	0	0	0	0	0	0	85	5	V	2
Phalacrocorax auritus		(1)	(3)	(2)												
9. Great Blue Heron	0	0	0.6	0.2	0	0.4	0.2	0	0	0	0	0	43	4	N	1
Ardea herodias			(1)	(1)		(1)	(1)									
10. Trumpeter Swan	0.2	0	1.4	7.2	0	0	0	0	0	0	2.4	0	11	5	V	0
Cygnus buccinator	(1)		(5)	(22)							(9)					
11. Greater White-fronted Goose *Anser albifrons*	0	0	0	0	0	0	0	0	1	0	0	0	1	1	—	0
12. Canada Goose	6.0	4.0	4.2	4.8	6.6	17.0	26.6	30.8	21.2	14.4	16.5	15.0	4 858	5	DN	2
Branta canadensis	(12)	(12)	(12)	(12)	(13)	(47)	(52)	(52)	(32)	(24)	(33)					
13. Green-winged Teal	0	0	0	6.0	1.8	1.6	1.4	2.5	2.2	2.0	0	0	425	4	DN	2
Anas crecca				(20)	(2)	(8)	(7)	(6)	(4)	(6)						
14. Mallard	0.6	15.8	1.6	6.0	2.5	6.8	0.2	1.0	7.4	56.8	112.5	100.0	7 820	5	D	0
A. platyrhynchos	(2)	(50)	(6)	(20)	(4)	(30)	(1)	(3)	(15)	(110)	(202)					
15. Northern Pintail	0	0	0	15.0	0	0	0	0	3.0	0	0	0	33	2	V	0
A. acuta				(30)							(6)					
16. Northern Shoveler	0	0	0	1.3	3.0	0	0	0	0	0	0	0	17	3	V	0
A. clypeata				(4)	(6)											
17. American Wigeon	0	0	0	7.5	0	0	0	0	2.0	2.5	0	0	31	2	V	0
A. americana				(15)					(4)	(5)						
18. Ring-necked Duck	0	0	1.0	3.5	0	0	0	0	0	0	0	0	14	2	V	0
Aythya collaris			(2)	(7)												

19. Scaup	0	0	0	0.4	6.0	3.6	0.3	0.3	1.6	0.3	1.6	2.0	208	5	V	1
Aythya spp.				(2)	(10)	(8)	(1)	(1)	(5)	(1)	(5)					
20. Oldsquaw	0.2	0.2	0.6	0.4	0.2	0	0	0	0	0	0.2	1.0	61	4	DN	2
Clangula hyemalis	(1)	(1)	(1)	(1)	(1)						(1)	1.0				
21. Surf Scoter	0	0	0	0.7	0	0	0.7	0	1.3	0	0	0	8	3	V	0
Melanitta																
perspicillata				(1)			(1)		(3)							
22. White-winged Scoter	0	0.2	0.2	1.0	2.0	0.4	1.0	0.4	0.6	11.4	3.2	0	207	5	V	—
M. fusca		(1)	(1)	(3)	(2)	(2)	(2)	(2)	(1)	(50)	(15)	0				
23. Common Goldeneye	0	0	0.6	0	0	0	0	0	0.3	0	1.0	0	11	3	V	0
Bucephala clangula			(2)						(1)		(3)					
24. Bufflehead	0.6	1.0	3.0	6.4	3.0	0	0	0	0	3.0	1.0	2.0	608	5	DN	2
B. albeola	(2)	(2)	(5)	(12)	(5)					(6)	(2)					
25. Hooded Merganser	0	0	0	0.5	0.3	0.5	0.5	3.3	4.0	1.5	0	0	322	4	DN	2
Lophodytes																
cucullatus				(2)	(1)	(1)	(1)	(7)	(6)	(4)						
26. Common Merganser	0.8	1.2	6.8	10.2	30.0	0.5	0.2	0	56.5	88.5	0.8	4.0	3 553	5	N	1
Mergus merganser	(3)	(3)	(22)	(12)	(75)	(1)	(1)		(104)	(124)	(2)					
27. Red-breasted																
Merganser	0	0	1.0	0	0	0	0	0	0	0	0	0	1	1	N	0
M. serrator																
28. Greater Yellowlegs	0	0	0	0	0	0	1	1	1	0	0	0	84	3	V	2
Tringa melanoleuca																
29. Wandering Tattler	0	0	0	0	1	0	0	0	0	0	0	0	2	1		2
Heteroscelus incanus																
30. Spotted Sandpiper	0	0	0	0	0	0	0	1	1	0	0	0	55	2	V	2
Actitis macularia																
31. Red Phalarope	0	0	0	0	0	0	0	0	0	0	1	0	4	2	—	2
Phalaropus fulicaria																
32. Bonaparte's Gull	0	0	0	0	0	0	1	0	0	0	0	0	1	1	D	0
Larus philadelphia																
33. Glaucous-winged																
Gull	0	0	0.4	3.8	2.0	3.4	3.6	3.5	2.0	0	0.4	0	581	5	N	0
L. glaucescens			(2)	(5)	(2)	(8)	(6)	(5)	(2)							
34. Marbled Murrelet	0	0	0	0	0	0	2	0	0	0	0	0	2	2	N	0
Brachyramphus																
marmoratus																
35. Belted Kingfisher	0.2	0.5	1.2	1.8	1.2	1.0	1.2	1.0	1.0	1.2	1.3	2	353	5	D	2
Ceryle alcyon	(1)	(1)	(2)	(2)	(2)	(1)	(2)	(1)	(1)	(2)	(4)					
36. American Dipper	0	0	0	0	0	0	0	0	0	0	1	0	1	1		—
Cinclus mexicanus																

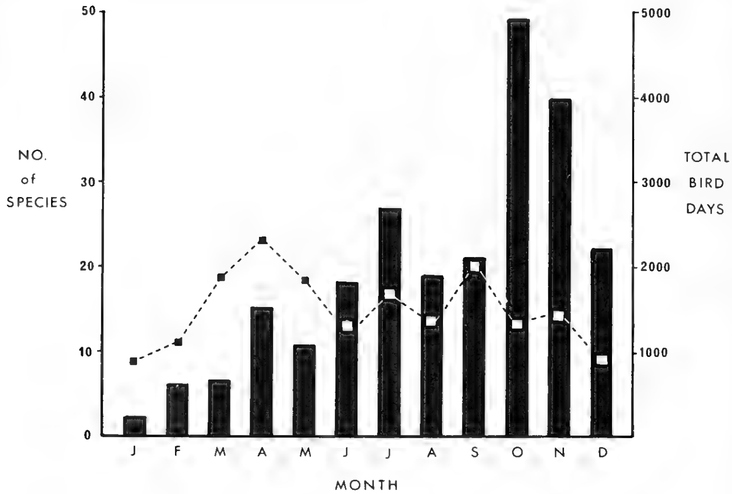

FIGURE 2. Monthly abundance of aquatic species (dashed), and total bird-days (histogram).

Discussion

Most birds observed on Drizzle Lake are within their known breeding, migratory or winter ranges (Godfrey 1966; Bellrose 1980), and had been noted during earlier coastal surveys on the Queen Charlotte Islands (Osgood 1901; Patch 1922; Darcus 1930; Cumming 1931). Green-winged Teals had not been reported as breeding on the Islands (Godfrey 1966); it is unlikely that our records represent a recent extension of their breeding range, as "juvenile" teal were observed on an adjacent lake in 1919 (Patch 1922). Pied-billed Grebe and Ring-necked Duck were north of their known coastal ranges. The assemblage of species and their seasonal occurrence is probably representative of many lakes on the Argonaut Plain although numbers of individuals will vary according to lake size and limnological conditions. Most species were also observed on a 18 ha lake 30 km south (Reimchen 1980 and unpublished data).

Despite its location along a major Pacific flyway and proximity to the ocean, Drizzle Lake was not a feeding area for migratory geese, ducks or shorebirds; it was used only for short periods by small numbers of migrants. Seabirds, such as alcids and petrels, which breed in large colonies on the coast of the Queen Charlotte Islands (Summers 1974; Sealy 1976), did not frequent the lake during any period of the year, with the exception of the occasional Marbled Murrelet, which probably nests in adjacent forests.

There was regular seasonal habitation of the lake by

TABLE 2. Principal utilization of aquatic habitat observed at Drizzle Lake from 1978 to 1982. See Table 1 for species. *migrants present for less than 5 d/y.

Category	Species	No. of species	Total Bd. Days	% of total Bd. Days
Migrant*	7,10,11,12,13,15 16,17,18,21,22,23 27,28,29,30,31,32,36	19	170	0.7
Seasonal Resident				
Breeding	1,12,13,14,25	5	1 710	7.3
Non-breeding	2,3,4,5,6,12,24	7	3 068	13.1
Ocean/Lake Daily Itinerants				
Foraging frequent	3,8,12,20,28,35	6	4 899	21.0
Foraging absent or uncommon	1,9,14,19,21,22 26,33,34	9	13 537	57.9

both foraging and non-foraging birds. Major utilisation, in total bird-days, was by individuals which moved to and from the ocean on a daily basis, doing the majority of their feeding in nearshore marine waters. That individuals leave their foraging habitat and return to an inland lake suggests a requirement of fresh water in the diet or for plumage maintenance, since each species drinks and preens extensively following its arrival. Lakes also lack disturbance from tidal movement and probably have lower densities of predators (mammals, raptors and large fish) than the coastline or open ocean.

Foraging piscivores occurred on the lake throughout the year, usually in small numbers. For those species which foraged throughout the day (resident Common Loon, Red-necked Grebe, Horned Grebe, Double-crested Cormorant, Hooded Merganser, Oldsquaw and Belted Kingfisher), yearly weight of fish consumed may be estimated from the equation $\log F = -0.293 + 0.850 \log W$, where F is the g fish consumed per day and W is the weight of the bird (g) (Nilsson and Nilsson 1976) (mean bird weights obtained from Terres 1980 and R. W. Campbell, British Columbia Provincial Museum, personal communication). This yields a total of 295 kg or 0.26 g/m^2 of fish consumed yearly, which is a minimum estimate, as it includes only consumption by seasonal residents. Food consumption by itinerants such as summering Common Loons is more difficult to estimate as they remain approximately 4 h per day on the lake and only about 50 % of the birds forage (Reimchen and Douglas 1980). Only 15 % of the Red-throated Loons foraged during their nightly occupation of the lake, generally for less than 1 h. On the (unrealistic) assumption that the loons obtained all their caloric requirements during those short periods, prey consumption by itinerants could equal 278 kg/y. That would increase the total fish consumption to 573 kg/y for all species or 0.51 $g/m^2/y$ and would represent a maximum estimate. Common Loons accounted for 59 % of the total. Although comparable data are not available for other coastal lakes in British Columbia, analysis of prey consumption by birds at a large oligotrophic lake (4400 ha) in Sweden yielded a total of 0.78 $g/m^2/y$ (Nilsson and Nilsson 1976); Common Mergansers accounted for 62 % of total fish consumption there. At Drizzle Lake, this species was the most common piscivore, yet it rarely foraged. In coastal marine waters of the north Pacific, values for food consumption by birds (including non-piscivores) range from 0.7 to 8.0 $g/m^2/y$ (Schneider and Hunt 1982).

The relatively consistent numerical and seasonal occurrence of the aquatic species observed in this survey provides a useful baseline for assessing temporal changes in the habitat. It is not possible to determine whether the data are representative as equivalent surveys have not been made at other lakes in British Columbia. Major nocturnal habitation by some species must be considered if future surveys of this and other systems are to be comparable.

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Établissement du Goéland à bec cerclé, *Larus delawarensis*, au Québec

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Mousseau, Pierre. 1984. Établissement du Goéland à bec cerclé, *Larus delawarensis*, au Québec. Canadian Field-Naturalist 98(1): 29–37.

Au cours des trente dernières années, le Goéland à bec cerclé (*Larus delawarensis*) a colonisé le Québec méridional. Mises à part deux anciennes populations restreintes sur la côte nord du golfe du Saint-Laurent et sur les rives de la baie James, la première mention de nidification au Québec remonte à 1953 à l'île Moffat, en face de Montréal. Durant les 25 années suivantes, des colonies se sont établies sur la rivière des Outaouais et d'ouest en est le long du fleuve Saint-Laurent; l'augmentation des effectifs sur les sites de nidification s'accompagnait de l'extension de l'aire de nidification. Depuis 1978, des colonies ont apparu dans l'intérieur des terres. Il y aurait actuellement au Québec 30 colonies connues totalisant plus de 43 000 couples. Cette colonisation fait suite à l'explosion démographique observée dans les Grands Lacs dès 1940, mais surtout au cours des années 1960. Par ses activités, l'homme a mis à la disposition de cette espèce opportuniste des sites adéquats de nidification et des sources alimentaires variées qui ont favorisé cette colonisation. Actuellement, 70% des goélands nicheurs du Québec sont concentrés dans la région de Montréal où les 16 000 couples de l'île de la Couvée constitue la quatrième plus importante colonie de l'espèce. La croissance rapide de cette population n'apparaît pas pour l'instant problématique.

Mots clés: Goéland à bec cerclé, *Larus delawarensis*, dynamique de population, colonies, Québec, Laridae.

The Ring-billed Gull (*Larus delawarensis*) settled in Southern Quebec in the last 30 years. Except for two old populations restricted to the North Shore of the Gulf of St. Lawrence and the shores of James Bay, the first record of breeding occurred in 1953 on Moffat Island off Montreal. In the next 25 years, the Ring-billed Gull established itself on the Ottawa River and eastward on the St. Lawrence River; the increase of the breeding population and the range extension were almost simultaneous. Occupancy of inland sites started in 1978. There are now in Quebec 30 colonies totaling over 43 000 breeding pairs. The arrival in Quebec of this gull followed the tremendous increase of its Great Lakes population as early as 1940, but mainly in the 1960's. Man's actions provided this opportunistic gull with adequate breeding sites and various food supplies. Seventy per cent of the breeding gulls of the province are now found in the Montreal area where the 16 000 pairs of Ile de la Couvée constitute the fourth largest colony of the species. The rapid increase of this gull population does not pose problems for the time being.

Key Words: Ring-billed Gull *Larus delawarensis*, population dynamics, colonies, Quebec, Laridae.

Le Goéland à bec cerclé est probablement une des espèces indigènes de l'Amérique du Nord qui a le plus profité de la présence de l'homme. Etabli originellement sur la côte nord du golfe du Saint-Laurent et dans la Prairie du sud du Canada et du nord des États-Unis, ce goéland a envahi la région des Grands Lacs à compter de 1926; depuis 1960, les effectifs nicheurs ont augmenté dans certaines régions (Ludwig 1962, 1974; Conover et al. 1979) et l'espèce n'a pas cessé d'étendre son aire (Ludwig 1974; David et al. 1978). Dans cet article, nous ferons le point sur l'état de cette espèce au Québec en relatant l'historique de son expansion à la lumière de ce qui s'est passé ailleurs en Amérique du Nord et en examinant les principales causes de ces phénomènes ainsi que ses conséquences possibles.

Méthode

L'historique de l'établissement du Goéland à bec cerclé au Québec a été reconstitué en puisant dans la littérature inédite et publiée. De 1978 à 1981, l'auteur a dénombré les nids de chacune des 6 colonies de la région de Montréal; en 1982, seule la colonie de l'île de la Couvée a été inventoriée.

Résultats

Historique de l'établissement de la nidification au Québec

Cette section retrace l'établissement du Goéland à bec cerclé au Québec selon l'ordre chronologique des régions occupées; d'après les observations disponibles, seules les mentions certaines de nidification ont été retenues. Les noms des entités géographiques sont tirés du Répertoire toponymique du Québec qui fournit également leur localisation; pour la localisation des refuges de la Côte-Nord, Lewis (1925), entre autres, pourra être consulté. Le texte donne les coordonnées géographiques des lieux non répertoriés dans ces deux références.

Côte-Nord

La première mention de nidification de l'espèce au

Québec provient de la côte nord du golfe du Saint-Laurent. En 1833, Audubon (*in* Todd 1963) a observé une colonie d'environ 200 couples à l'île du Petit Mecatina. Plus tard en 1884, Frazar (1887) a trouvé quelques colonies (effectifs non indiqués) dans la région du cap Whittle. Puis en 1915, une autre colonie d'environ 500 oiseaux est notée près de la pointe à Maurier, 30 km au nord-est du cap Whittle (Townsend 1917). De 1925 à 1982, 12 recensements quinquenaux d'oiseaux marins ont été réalisés par des organismes fédéraux dans des refuges de la Côte-Nord (Tableau 1).

En 1940, Lewis (1941) établissait la population de la Côte-Nord à 1769 couples (3538 individus) répartis selon leur localisation en 5 différents groupes: (1) îles à l'ouest de l'embouchure de la rivière Kegashka, (2) groupe d'îles près de l'île à la Brume, (3) îles de la pointe à Maurier, (4) refuge de Mécatina, (5) refuge de Saint-Augustin (Tableau 1). Aujourd'hui, soit entre 1977 et 1982, environ 7 colonies totalisant 3406 individus seraient présentes sur la Côte-Nord: (1) île à l'embouchure de la rivière Jupitagon, (2) île à proximité du refuge de Betchouane, (3) refuge Watshishou, (4) île Kippin, (5) refuge de l'île à la Brume, (6) refuge des îles aux Perroquets, (7) refuge de Saint-Augustin (Tableau 1).

Baie James

La première mention de nidification dans cette région remonte à 1912: 2 nids sur une petite île au nord de l'embouchure de la rivière Eastmain (Todd 1963). Seulement trois autres mentions ont été notées dans cette région: (1) à l'endroit précédent en 1926 (Todd 1963), (2) 2 nids en 1941 sur le rocher Barbeteau (51° 41′ N, 79° 00′ O) dans la baie de Rupert (Todd 1963), (3) 36 nids en 1972 (A. Bourget, SCF, communication personnel) aux rochers Dufourmentel (51° 40′ N, 79° 03′ O) dans la baie de Rupert (Territoires du Nord-Ouest).

Région de Montréal

De rare visiteur de passage à la fin du siècle dernier (Wintle 1896), l'espèce est devenue commune lors de ses migrations à compter de la fin des années 1930 (Anonyme 1935-1965). Ce n'est qu'en 1953 que l'espèce fut trouvée nicheuse, sur l'île Moffat, lieu qu'elle fréquentait déjà depuis plusieurs années; puis seulement 7 ans plus tard, en 1960, 5 000 oiseaux y nichaient (Anonyme 1935-1965). En 1963, l'île Moffat a été abandonné par les goélands à cause des travaux de remblayage pour la création de l'île Notre-Dame (site de l'Expo 1967).

Durant les quinze années suivantes, les goélands occupent temporairement divers sites de nidification: au pied des rapides de Lachine, l'île Target avec 150 nids en 1965 et l'île Cable avec 500 nids en 1965, 350 nids en 1967 et 1968 (Fichier de nidification des oiseaux du Québec, FNOQ) et quelques nicheurs en 1982; l'île Verte avec 10 000 oiseaux en 1967 (M. Bureau, MLCP, communication personnel) et 300 nids en 1971 (attribués à tort au Goéland argenté, *Larus argentatus*; Anonyme 1971); l'île aux Goélands (45° 44′ N, 73° 25′ O) fréquentée depuis 1971, avec 434 nids en 1977 (L.-M. Soyez, MLCP, communication personnel). La hausse du niveau de l'eau a possiblement été la cause de l'abandon de l'île Verte (Y. Gauthier et M. Lepage, MLCP, données inédites) et de l'île aux Goélands complètement submergée en 1978.

Entre 1967 et 1971, l'espèce a colonisé l'île de la Couvée. Cette île de remblai, construite vers 1959 et bordant la voie maritime au niveau du pont Champlain, supportait en 1972 une colonie de plusieurs centaines de nids; en 1974, sa population était estimée à 4 000 nids (SCF, données inédites). L'effectif nicheur a passé de 10 910 nids en 1978 à 16 093 en 1982, soit une augmentation de près de 50% en 4 ans (Tableau 2).

L'île Deslauriers, occupée depuis 1978 (L.-M. Soyez, communication personnel) est la colonie de la région qui a montré la plus forte croissance de sa population. De 1978 à 1981, une augmentation (de 165%) du nombre de nids est notée (Tableau 2).

Depuis 1974 (M. Lepage, données inédites), 4 sites, situés dans la portion nord de l'archipel de Contrecoeur, sont occupés: (1) l'île Saint-Ours avec 3 979 nids en 1976 (FNOQ) et 1 169 nids en 1981, (2) la butte ouest de l'îlet à Lefebvre avec une augmentation annuelle des nids de 1975 à 1981 pour atteindre 1 530 nids, (3) la butte est de l'îlet à Lefebvre avec une augmentation annuelle des nids de 1975 à 1980 pour se situer à 2 629 nids en 1981, (4) l'île de la Petite Colonie avec une augmentation entre 1975 et 1981 pour atteindre 3 472 nids (Tableau 2).

D'après nous, la population nicheuse du Goéland à bec cerclé de la région de Montréal est passée de 21 876 à 28 471 couples entre 1978 et 1981, soit une augmentation de 30%; les populations des îles de la Couvée et Deslauriers, 50% et 19% respectivement des effectifs de la région, affichent des augmentations alors que celles des îles de Contrecoeur (31%) sont stables, les oiseaux quittant l'île Saint-Ours allant apparemment s'établir dans les colonies voisines (Tableau 2).

Région de Hull

Depuis au moins 1966, une île en aval de la chute des Chaudières serait occupée par le Goéland à bec cerclé (J. Chabot, MLCP, données inédites). Ces dernières années, quatre colonies ont été observées du côté québécois de la rivière des Outaouais entre Hull et

TABLEAU 1. Effectifs nicheurs du Goéland à bec cerclé sur la côte nord du golfe du Saint-Laurent.

Lieu	Années																			
	1833[a]	1884[a]	1915[b]	1925[c] *	1930[d] *	1935[e] *	1936[f]	1940[g] *	1940[f]	1945[h] *	1950[i] *	1955[j] *	1960[k] *	1965[l] *	1972[m] *	1976[n]	1977[o] *	1978[p]	1978[q]	1982[r] *
Rivière Jupitagon																		300		
Refuge de Betchouane										275	150	714	500	150			1038		1962	1
Refuge de Watshishou																	2			24
Rivière Kegashka									2056											
Île Kippin																		200		
Refuge de l'île à la Brume				210	26			270	270	110		1762	135	150	3		122			178
Refuge de la baie des Loups						30							466							
Cap Whittle		+																		
Refuge des îles aux Perroquets																				188
Pointe à Maurier			500						1084											
Île du Petit Mécatina	400																			
Refuge de Mécatina				60	50			68	70	50	50						NI			NI
Refuge de Saint-Augustin					300	314		58	58	400		314	1300		445		554			NI
Île Galibois																202				
Rochers Flat							400													
Total	400	+	500	270	376	344	400	396	3538	835	200	2790	2401	300	448	202	1716	500	1962	391

Références

[a]Todd 1963
[b]Townsend 1917
[c]Lewis 1925
[d]Lewis 1931
[e]Lewis 1937
[f]Lewis 1941
[g]Lewis 1942
[h]Hewitt 1950
[i]Tener 1951
[j]Lemieux 1956
[k]Moisan 1962
[l]Moisan et Fyfe 1967
[m]Nettleship et Lock 1973
[n]Chapdelaine, SCF, donnée inédites
[o]Chapdelaine 1980
[p]Dupuis (comm. pers.)
[q]Chapdelaine et Bourget 1981
[r]Chapdelaine et Brousseau, 1984

* Année d'un inventaire quinquenal
NI Non inventorié lors des inventaires quinquenaux

TABLEAU 2. Effectifs nicheurs (nombre de nids) des colonies du Goéland à bec cerclé de la région de Montréal.

Sites de nidification	Année du dénombrement						
	1975[1]	1976[1]	1978	1979	1980	1981	1982
Île de la Couvée	—	—	10 910 (49,9)[2]	15 228[1] (53,9)	14 732 (50,2)	14 331 (50,3)	16 093
Île Deslauriers	—	—	2 012 (9,2)	4 413 (15,6)	4 961 (16,9)	5 340 (18,8)	—
Ensemble des îles de Contrecoeur	—	6 151	8 954 (40,9)	8 595 (30,4)	9 626 (32,8)	8 800 (30,9)	—
Îlet à Lefebvre (butte ouest)	108	248	805 (3,7)	548 (1,9)	1 330 (4,5)	1 530 (5,4)	—
Îlet à Lefebvre (butte est)	214	672	2 339 (10,7)	2 718 (9,6)	3 178 (10,8)	2 629 (9,2)	—
Île de la Petite Colonie	424	1 252	3 231 (14,8)	2 988 (10,6)	3 323 (11,3)	3 472 (12,2)	—
Île Saint-Ours	+[3]	3 979	2 579 (11,8)	2 341 (8,3)	1 795 (6,1)	1 169 (4,1)	—
Total	—	—	21 876 (100,0)	28 236 (99,9)	29 319 (99,9)	28 471 (100,0)	—

[1]Données inédites du Service canadien de la faune, Environnement Canada
[2]Fréquence relative (%)
[3]Présence mais aucun dénombrement

Rapide-des-Joachims: 1) île en aval de la chute des Chaudières avec 150 nids en 1981 (J. Chabot, MLCP, données inédites); 2) l'île Chaudière (45° 25′ N, 75° 44′ O) avec 200 nids estimés en 1979 (P. Mousseau et M.-C. Lagrenade, données inédites) et 478 nids en 1980 (Cooper et al. 1982); 3) île en amont du pont Prince of Wales avec au moins 179 nids en 1979 (P. Mousseau et M.-C. Lagrenade, données inédites) et 446 nids en 1980 (Cooper et al. 1982);) île de la baie Black (45° 28′ N, 76° 17′ O) en amont de Quyon avec 138 nids en 1981 (J. Chabot, MLCP, données inédites). D'autres colonies totalisant plus de 550 nids sont présentes du côté ontarien (J. Chabot, MLCP, données inédites; Cooper et al. 1982).

Région du Québec

Les premières mentions de nidification dans la région de Québec remontent à 1971 près de Montmagny, soit à l'île à Durand avec 250 couples estimés et l'îlot Le Pilier de Fer avec 650 nids (Reed 1974). En 1979, les deux colonies précédentes atteignaient respectivement 686 et 4 981 nids (nids vides exclus) et une troisième colonie à l'île Bellechasse s'ajoutait avec 1 060 nids (J.-L. DesGranges et R. Angers, SCF, données inédites). En 1983, une quatrième colonie de 1 400 nids a été trouvée dans le port de Québec (P. Perreault, communication personnel). Ainsi, le nombre de nids dans cette région a passé de 900 en 1971 à 8 127 ces dernières années. Un cas de nidification isolé dans une colonie du Goéland argenté a été rapporté à l'île aux Basques (Anonyme 1978).

Autres régions

Plusieurs autres régions du Québec ont été occupés par l'espèce depuis 1973 et surtout depuis 1978. Ce sont, par ordre chronologique, celles de Baie-Comeau, du Saguenay-Lac-Saint-Jean, de l'Estrie, de Mont-Laurier et de la Gaspésie.

À Baie-Comeau, une colonie présente en 1973 sur des déchets de bois (Y. Garon, communication personnel) était occupée par 1 200 couples en 1978 (G. Chapdelaine, SCF, communication personnel). Au Saguenay-Lac-Saint-Jean, sur 2 amas de roches près de l'embouchure de la rivière Péribonka, 30 nids ont été notés en 1978 (FNOQ) et 150 adultes accompagnés de jeunes en 1982 (N. David, CREM, communication personnel). Il faut noter aussi la présence de rassemblements estivaux sur des amas de roches dans la baie-des-Ha! Ha! depuis au moins 1974; en 1983, environ 35 nids occupaient le site le 20 juillet (N. Breton, communication personnel). Dans l'Estrie, au réservoir Choinière (45° 25′ N, 72° 37′ 0) deux îlots créés en 1978 étaient occupés par 3 nids en 1979 (Boily 1983), 56 nids en 1980 (P. Mousseau), 33 nids en 1981 (Y. Morin, communication personnel) et 23 nids en 1982 (J. Legris, communication personnel). La diminution récente est causée par un dérangement humain fréquent. Dans la région de Mont-Laurier, deux îlots rocheux du réservoir Baskatong supportaient 89 nids sur l'un et au moins 90 nids (estimation) sur l'autre (J. Chabot, MLCP, données inédites). La mention de nidification la plus récente dans une nouvelle région est celle de Carleton en Gaspésie. Quelques adultes et des poussins ont été observés en 1982 et un rassemblement estival avait été noté depuis quelques années (P. Fallu, communication personnel). Ces individus proviennent peut-être de la colonie de Bathurst au Nouveau-Brunswick de l'autre côté dans la baie des Chaleurs (40 couples en 1972; Squires 1976). L'espèce est aussi susceptible de nicher ailleurs en Gaspésie

(New-Richmond, Bonaventure, Port Daniel, Chandler et Barachois) car des attroupements estivaux y sont notés à chaque année (R. Bisson, SCF, communication personnel).

De plus, 5 autres endroits ont été le site de nidification infructureuses ou de tentatives de nidification: (1) îlot de la rivière Saint-François dans la municipalité de Sherbrooke avec 1 nid inondé en 1978 et 7 nids inondés en 1980 (Boily 1983), (2) îlot à la tête de la rivière Magog avec 25 nids perturbés par la présence humaine en 1981 (Boily 1983), (3) berge nord du lac Memphrémagog avec 150 nids en 1982, le site ayant été partiellement nivellé (Boily 1983), (4) îlot de la Voie maritime face à La Prairie avec 13 nids en 1979 et 4 nids en 1980, aucun poussin n'ayant été observé et la majorité des goélands étant des immatures, (5) un îlot du lac Pelletier au sud-ouest de Rouyn où un jeune en duvet a été observé avec 6 adultes en 1978 (J. Chabot, MLCP, données inédites).

Discussion

État de la population québécoise

Une compilation des mentions récentes indique que la population globale actuelle du Goéland à bec cerclé au Québec comprend au moins 30 colonies et 43 300 couples (Figure 1 et Tableau 3). L'abondance réelle pourrait certainement dépasser les 43 300 couples compte tenu du fait que les relevés datent de quelques années dans certaines régions.

Sur la Côte-Nord, se trouve une partie du peuplement initial du Goéland à bec cerclé en Amérique du Nord. Sa population serait relativement stable depuis au moins 40 ans. Toutefois, l'estimation de cette population est imprécise car elle provient d'inventaires étalés sur plusieurs années, ne couvrant pas l'ensemble de la Côte-Nord. Les données des recensements quinquenaux (Tableau 1) ne représentent qu'une partie de la population de la Côte-Nord car en 1940, Lewis (1941) a noté 200 couples dans les refuges et 1 569 couples à l'extérieur des refuges. De plus, les colonies de la Côte-Nord changent fréquemment de sites de nidification (Chapdelaine et Bourget 1981) à cause, dans certains cas, du pillage des nids (Nettleship et Lock 1973) et possiblement pour d'autres cas du déplacement temporaire de la ressource alimentaire (Tener 1941).

Il est impossible de dire si la population de la baie James est aussi ancienne que celle de la Côte Nord ou si elle s'y est installée plus tard. Cependant les effectifs de cette population sont toujours demeurés très faibles.

La situation est tout à fait différente dans la région de Montréal. Cette dernière est le coeur de la population du Québec. Avec au moins 150 couples en 1953, cette région est fréquentée par plus de 30 000 couples en 1982 répartis dans 6 colonies et représentant près de 70% des effectifs de la province; plus de 40% sont rassemblés sur un même site, l'île de la Couvée. Cette île avec ses 16 000 couples serait parmi les 4 plus importantes au monde après celles de la pointe Leslie (67 000 couples en 1980: Cooper et al. 1982; 75 000 couples estimés en 1982: Blokpoel et Tessier 1982), de l'île Little Galloo (27 308 couples en 1977: Scharf et al. 1978; 73 780 nids en 1981: Blokpoel et Weseloh 1982) et l'île Gull (23 707 couples en 1976: Blokpoel 1978), toutes trois situées au lac Ontario.

Au moment où les goélands de la région de Montréal sont à la recherche de sites adéquats, se produit l'apparition de colonies sur la rivière des Outaouais près de Hull et, probablement en même temps, dans l'estuaire du Saint-Laurent près de Montmagny et aussi, peu de temps après, à Baie-Comeau un peu plus à l'est. Parmi ces régions, c'est celle de Québec qui est la plus importante avec 19% des couples nicheurs du Québec (Tableau 3). Selon les données de Cooper et al. (1982) et les nôtres (données inédites), la population de la région de Hull afficherait une augmentation marquée surtout depuis 1977. Par ailleurs, il est impossible de statuer sur l'origine des oiseaux qui nichent à Baie-Comeau.

Au même moment où plusieurs colonies montrent de fortes augmentations de leurs effectifs, spécialement dans les régions de Montréal et Hull, on assiste à l'apparition de plusieurs nouvelles colonies un peu partout dans le sud du Québec. Cette fois, mis à part le site de Carleton, les goélands ne se retrouvent plus le long des grandes voies d'eau mais plutôt à l'intérieur des terres. Ces 7 nouvelles colonies représentent, pour l'instant, à peine 1% des effectifs de la population du Québec (Tableau 3).

La population québécoise et les populations nord-américaines

Ce phénomène d'accroissement des populations observé au Québec n'est pas unique et est étroitement relié à la dynamique de la population nord-américaine.

À la fin du siècle dernier, le Goéland à bec cerclé nichait aux lacs Huron et Michigan, à certains endroits en grand nombre; de 1906 à 1926, il ne semble pas y avoir niché (Ludwig 1943). Cette disparition temporaire est peut-être liée à la demande importante de plumes d'ornement à la fin du 19e siècle (Weseloh et Blokpoel 1979); depuis 1916, l'espèce est protégée contre cette pratique par le traité sur les oiseaux migrateurs. Le retour de l'espèce dans la portion nord du lac Michigan et au lac Huron s'est produit dès 1926 (Ludwig 1943). En 1930, la population totale des Grands Lacs est estimée à 3 000 couples répartis aux lacs Ontario et Huron; une augmentation importante de la population s'étant produite, elle atteint près de

40 000 couples en 1945: 15 000 au lac Ontario, 20 000 au lac Huron, et 2 000 sur la section ontarienne du fleuve Saint-Laurent constituant une extension de l'aire de reproduction vers l'est. Après 1945, on assiste à une explosion démographique (très forte entre 1960 et 1967) de sorte que 335 000 couples occupent en 1967 l'ensemble des Grands Lacs (principalement les lacs Ontario et Huron) ainsi que la portion ontarienne du fleuve Saint-Laurent (Ludwig 1974).

Ce phénomène de croissance ne semble pas s'être arrêté. À la pointe Leslie dans le port de Toronto, on comptait 21 couples en 1973 (Blokpoel et Fetterolf 1978), 10 382 en 1976 (Blokpoel 1978), 67 000 en 1980 (Cooper et al. 1982) et plus de 75 000 en 1982 (Blokpoel et Tessier 1982). De plus, Scharf et al. (1978) ont enregistré une augmentation de la population américaine des Grands Lacs de 10% entre 1976 et 1977, portant le nombre de couples nicheurs à plus de 102 000.

Un tel accroissement de population n'a pas manqué de produire une extension de l'aire de nidification de l'espèce. Ainsi l'établissement de 2 000 couples dans la portion ontarienne du fleuve Saint-Laurent en 1945 s'est consolidé car 5 000 couples y nichaient en 1967 (Ludwig 1974). C'est d'ailleurs à la fin des années 40 que l'établissement de l'espèce a été noté dans la région de Montréal, à l'île Moffat. Puis peu de temps après l'augmentation fulgurante notée aux lacs Michigan et Huron entre 1960 et 1967, les régions de Hull, Québec et Baie-Comeau sont occupées ainsi que l'intérieur des terres ces dernières années.

L'Alberta et l'ouest des États-Unis ont aussi été le site d'une croissance de population, mais moins importante que celles observées dans les Grands Lacs et au Québec. De 20 000 couples en 1968, la population de l'Alberta atteint 40 000 couples en 1977 (Weseloh et Blokpoel 1979). Depuis 1930, date de la première mention de nidification de l'espèce, l'état de Washington a vu sa population s'accroître pour atteindre 9 000 couples en 1977 (Conover et al. 1979; Conover et Conover 1981).

Causes de l'augmentation de ces populations

Le Goéland à bec cerclé est une espèce que l'on peut qualifier d'opportuniste. À cause de sa niche écologique étendue tant au niveau de l'habitat de nidification que de son régime alimentaire (Lagrenade et Mousseau 1981a, b), elle a su tirer profit de nombreuses modifications importantes de l'environnement. Ainsi dans les Grands Lacs, la très forte augmentation du début des années 60 a été favorisée par le contrôle du niveau de l'eau assurant la sécurité aux sites de nidification et par l'abondante source de nourriture représentée par le Gaspareau (*Alosa pseudoharengus*) aux lacs Michigan et Huron et l'Eperlan arc-en-ciel (*Osmerus mordax*) dans les autres lacs (Ludwig 1974).

L'augmentation de la population en Alberta semble être plutôt liée à la présence de dépôts d'ordures à proximité des grands centres urbains (Weseloh et al. 1977). Ces dépôts sont d'abondantes sources de nourriture pour les Goélands à bec cerclé (Vermeer 1970). Dans l'état de Washington, la croissance de la population résulte de certains facteurs comme la diminution de la prédation et, probablement avec plus d'importance, l'augmentation des ressources alimentaires découlant d'activités humaines telles que les exploitations agricoles et les dépôts d'ordures (Conover et al. 1979).

Au Québec, la croissance de la population a été plus importante dans les régions de Montréal et Québec. Dans ces régions les sites de nidification disponibles sont nombreux, surtout dans la région de Montréal depuis le début des années 60 avec la création d'îles de remblai lors des travaux de canalisation du Saint-Laurent. Ainsi à Montréal, le choix de site à l'abri des inondations printanières, la proximité d'opérations agricoles favorables sur la rive sud du fleuve Saint-Laurent et la multiplication des casse-croutes procurant une source additionnelle de nourriture, sont tous des facteurs qui ont répondu aux exigences écologiques de l'espèce et favorisés la croissances de sa population au cours des années 1970. La population de la Côte-Nord demeure stable probablement à cause de la cueillette des oeufs et d'un environnement non modifié au profit d'une expansion agricole ou urbaine comme c'est le cas dans la région de Montréal.

Cet envahissement du territoire québécois est favorisé, entre autres, par la disponibilité de sites adéquats pour la reproduction, un taux de reproduction élevé (P. Mousseau et M.-C. Lagrenade, données inédites, l'émigration, une longue espérance de vie (10 à 15 ans), son opportunisme alimentaire (Lagrenade et Mousseau 1981b), l'absence de prédateurs, l'absence de compétiteurs importants au niveau des ressources alimentaires et des sites de reproduction, son statut d'espèce protégée et sa facilité à tirer profit des activités humaines. Rien pour l'instant n'indique à quel niveau la population va se stabiliser. Toutefois ce phénomène n'est pas problématique actuellement.

Conséquences possibles de l'augmentation de la population québécoise

Par contre il est arrivé, ailleurs en Amérique du Nord, que cette augmentation des effectifs cause certains problèmes. Dans les Grands Lacs, ce phénomène a entraîné à certains endroits l'abandon par les Sternes pierregarins (*Sterna hirundo*) de sites de nidification à cause de la nidification plus hâtive des goélands (Ludwig 1962; Morris et Hunter 1976; Morris et al.

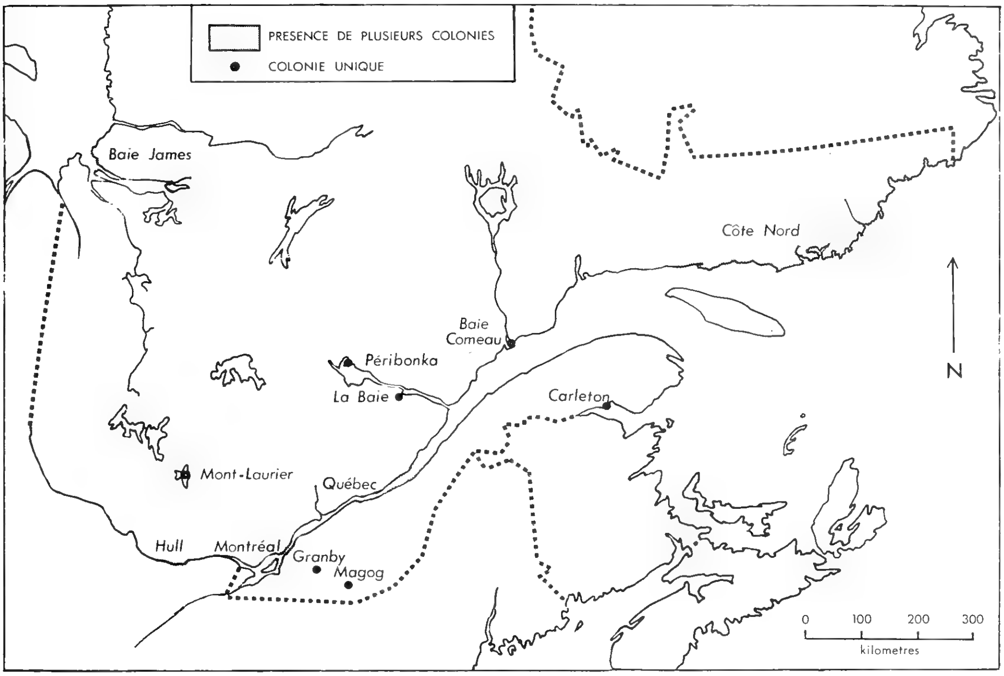

FIGURE 1. Répartition de la population actuelle du Goéland à bec cerclé au Québec.

TABLEAU 3. Nombre de colonies et effectifs nicheurs du Goéland à bec cerclé par région au Québec.

Régions	Année des mentions: première	Année des mentions: dernière	Nombre de colonies actuelles	Nombre de couples	Fréquence (%)
Côte-Nord	1833	1977-1982	7	1 700	3,9
Baie James	1912	1972	1	36	0,1
Montréal	1953	1981-1982	6	30 233	69,9
Hull	1966	1980-1981	4	1 200	2,8
Québec	1971	1979-1983	4	8 127	18,8
Baie-Comeau	1973	1978	1	1 500	3,5
Saguenay-Lac Saint-Jean	1978	1983	2	110	0,2
Granby	1979	1981	1	23	0,1
Magog	1978	1982	1	150	0,3
Mont-Laurier	1981	1981	2	179	0,4
Carleton	1982	1982	1	+	
Total			30	43 261	100,0

1976). Un tel comportement n'a pas encore été rapporté pour le Québec; la Sterne pierregarin n'est pas abondante aux endroits où le Goéland à bec cerclé l'est et, dans la région de Montréal, les sites de nidifications disponibles pour les deux espèces sont nombreux.

Mis à part le Pigeon biset (*Columba livia*), le Goéland à bec cerclé ne semble pas actuellement compétitionner avec d'autres espèces d'oiseaux. Les goélands fréquentent de plus en plus les parcs publiques où les gens nourrissent fréquemment les pigeons. Cette coexistence ne devrait pas nuire à ces espèces.

Enfin, la possibilité d'impacts contre des aéronefs et de transmission de maladies pour l'homme ne semblent pas non plus problématiques. De 1977 à 1981 aux aéroports de Dorval et de Mirabel, les incidents causés par les laridés (non dommageables pour l'avion) ne comptent en moyenne que pour 13% des impacts rapportés; ces impacts n'ont pas plus augmenté au cours des années que l'ensemble des impacts (A. J. LaFlamme, communication personnel). Par ailleurs, aucun cas d'ornithose n'a été rapporté au Québec, et ce même chez les aviculteurs; cependant lorsque de telles maladies se produisent ailleurs, les médecins ont de la difficulté à les diagnostiquer (J.-G. Lavoie, MENVIQ, données inédites).

En somme, même si l'explosion de la population ne semble pas problématique présentement, le phénomène mérite toutefois d'être suivi d'assez près, car cela n'est pas le cas en Ontario (H. Blokpoel, SCF, communication personnel).

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Food of Red-winged Blackbirds, *Agelaius phoeniceus*, in Sunflower Fields and Corn Fields

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The esophageal contents of 1182 Red-winged Blackbirds (*Agelaius phoeniceus*), collected from late July through early November in southwestern Cass County, North Dakota, showed no differences between after-hatching-year and hatching-year birds in the percentages of various food items consumed. Both males and females contained higher proportions of sunflower in sunflower fields than they did corn in corn fields. Males consumed more sunflower in sunflower fields and more corn in corn fields than did females, and females used more foxtail seeds (*Setaria* spp.) in both habitats than did males. Red-winged Blackbirds probably find sunflower easier to obtain than corn. The differences in percentage of various food items consumed by males and females may be related to body and bill size.

Key Words: Red-winged Blackbirds, *Agelaius phoeniceus*, food, corn fields, sunflower fields, North Dakota

Crop losses due to foraging flocks of Red-winged Blackbirds (*Agelaius phoeniceus*) are often serious and have prompted various, sometimes questionable, management programs (Dyer and Ward 1977; Weatherhead and Bider 1979). Control strategy must be based on knowledge of the diet and feeding behavior of the birds (Dyer and Ward 1977). Variations of food habits and feeding ecology of Red-winged Blackbirds in different areas may suggest different management strategies.

Food habits of Red-winged Blackbirds have been studied in corn production areas of Ohio (Williams 1975), South Dakota (Mott et al. 1972) and Ontario (Hintz and Dyer 1970; McNicol et al. 1982; Gartshore et al. 1982). Red-winged Blackbird food habits also have been studied in the rice-growing regions of Arkansas (Meanley 1971) and California (Crase and DeHaven 1978). To our knowledge, only Bird and Smith (1964) have published data on Red-winged Blackbird food habits in a sunflower production area (Manitoba).

Prior to 1966, sunflower acreage was small in North America (< 80 700 ha) and consisted largely of confectionery (non-oil) varieties grown for human snack foods and birdfeed (Helgeson et al. 1977). In 1983, sunflower acreage will probably exceed 2 million ha, 80% of which will be oilseed sunflower. Those varieties are used to produce high grade cooking oils and sunflower meal. To the distress of the sunflower growers, Red-winged Blackbirds may prefer oilseed varieties over confectionery varieties (Besser 1978).

In 1982, growers in southern Manitoba planted 200 000 acres of corn and 175 000 acres of sunflower. Monetary losses owing to blackbirds feeding in those crops potentially could exceed $2 000 000 (Harris, A. G. H., unpublished report). Thus, a significant reduction of bird damage would make those crops more attractive to growers. That is especially true for sunflower, which is often grown on marginal land near wetlands known to harbor large flocks of Red-winged Blackbirds during spring and fall migration.

During 1979 and 1980, we studied Red-winged Blackbird food habits in southwestern Cass County, North Dakota, a major oil sunflower production area. Other crops grown in the region included corn, barley, and wheat. All are potential food sources for Red-winged Blackbirds at various times of the year (Bird and Smith 1964; Hintz and Dyer 1970). Our objective was to study feeding patterns of various sex and age groups of Red-winged Blackbirds in an area where sunflower and corn are grown. This information may be used to redesign management programs aimed at reducing blackbird damage in those areas.

Study Area

Southwestern Cass County is on the east edge of the Drift Prairie physiographic region (Klausing 1968). The numerous wetlands in that agricultural area provide both daytime resting sites and night roosts for blackbirds (Icterinae). A principal roost is located in the Alice Waterfowl Production Area (U. S. Fish and Wildlife Service), which includes an approximately 300 ha cattail (*Typha* spp.) marsh. The surrounding land is intensively farmed, with 90% under cultivation. In 1980, 39% of the cultivated land was planted to wheat, 20% to corn, 17% to sunflower, 14% to barley, and only 10% to other crops (oats, soybeans, edible beans, flax, rye, millet, and sugar beets). On a

county basis, sunflower acreage was 38% higher in 1980 than in 1979 and wheat and barley 27% lower.

Methods

The esophageal contents of 1182 Red-winged Blackbirds were analyzed. They were collected by shooting, throughout daylight hours, from late July to early November 1979 and 1980, in sunflower fields and corn fields, with light to heavy weed growth. The specimens examined included: 439 after hatching-year (AHY) males, 238 AHY females, 344 hatching-year (HY) males, and 161 HY females. The birds were placed in plastic bags and packed in ice immediately after collection. Within five hours, the birds were processed or were frozen for later processing. Each bird was weighed, sexed, aged by plumage characteristics and presence or absence of the bursa of Fabricius (Wright and Wright 1944, Payne 1969), and assessed for stage of molt (Linz et al. 1983).

The Red-winged Blackbirds were collected from large feeding flocks (100-10000). From the birds obtained from any one flock, no more than five of each age-sex class were randomly chosen for analysis of esophageal contents. Esophagi were removed and placed in 95% ethanol. Later, the contents of each esophagus were emptied into a petri dish and examined under a stereomicroscope at 7X magnification. Food items were segregated and stored in 95% ethanol. Animal matter was identified only in 1979. Subsequently, each vial was emptied into preweighed plastic cups; the contents were air-dried to evaporate the ethanol, and oven-dried for 24h at 70°C. The contents were then cooled to room temperature and weighed. Food items weighing less than 0.01g were recorded only as "present", and were excluded from further analyses.

Analysis of variance on arcsin-transformed data was used to compare the proportion of various food items consumed by the different age-sex classes. Duncan's multiple range test was used to separate the means; $P < 0.05$ was accepted as significant.

Results

Red-winged Blackbirds in Sunflower

There were no differences ($P > 0.05$) between AHY and HY Red-winged Blackbirds in the percentage of various food items consumed in sunflower fields. Male Red-winged Blackbirds, collected in sunflower fields from 29 July through 4 November 1979 and 1980, contained more sunflower seeds (sunflower) and less foxtail (*Setaria* spp.) than the females ($P < 0.05$) (Table 1). During that period, 93% of the males and 86% of the females contained sunflower, which comprised 69% and 57% of the male and female diets, respectively. Concurrently, foxtail made up 18% of the male and 31% of the female diets and occurred in 65% of the males and 72% of the females. From 23 September to 4 November, the proportion of sunflower in the female diets decreased, and the percentage of foxtail increased, whereas the proportion of those foods in males remained the same compared to previous weeks.

The amount of animal matter consumed by male and female Red-winged Blackbirds in sunflower fields was highest from 12 August to 25 August, making up 25% of the male and 28% of the female diets. During the following ten weeks, animal matter comprised only 4% of the male and 5% of the female diets. In 1979, animal matter found in Red-winged Blackbirds feeding in sunflower fields included 20% beetles (Coleoptera), 16% aphids (Aphididae), 13% leafhoppers (Cicadellidae) and spittlebugs (Cercopidae) and 6% aphidlion larvae (Chrysopidae) (Table 2). Weevil larvae (Curculionidae) were commonly eaten from 23 September to 20 October.

Red-winged Blackbirds in Corn Fields

From 12 August to 20 October in 1979 and 1980, Red-winged Blackbirds were collected in corn fields. Males collected in corn fields contained more corn and less foxtail than the females collected there ($P < 0.05$) (Table 3). There were no differences ($P > 0.05$) between AHY and HY birds in the percentage of various food items consumed in corn fields. The proportion of corn in the esophagi of the males collected in corn fields was highest from 26 August to 6 October, when corn was found in 70% of the birds and made up 51% of their diet. During the same period, corn was found in 44% of the females and comprised 18% of their diet. Concurrent with peak corn use, 73% of the males and 90% of the females contained foxtail, which made up 38% and 71% of the male and female diets, respectively.

The proportion of animal matter in those Red-winged Blackbirds collected in corn fields was highest in August and tended to decrease as the season progressed (Table 3). Identification of the animal matter found in Red-winged Blackbirds feeding in corn fields in 1979 indicated that aphids, leafhoppers and spittlebugs, aphidlions, and spiders (Arachnida) were most prevalent (decreasing order of frequency) (Table 2).

Discussion

Studies comparing the food habits of male and female Red-winged Blackbirds have produced conflicting results. Mott et al. (1972), Williams (1975), and McNicol et al. (1982) showed that males consumed proportionally more corn than did females. Gartshore et al. (1982), however, found no differences in the relative amounts of corn consumed by male and female Red-winged Blackbirds.

TABLE 1. Percentage of weight and percentage of occurrence of food items in the esophagi of Red-winged Blackbirds collected in sunflower fields during 1979 and 1980 in southwestern Cass County, North Dakota.

	Time Period															
	29 July– 11 August		12 August– 25 August		26 August– 8 September		9 September– 22 September		23 September– 6 October		7 October– 20 October		21 October– 4 November		Totals	
Sex	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Number of birds	16	10	15	2	32	21	79	31	138	61	108	23	89	9	477	157
Mean Food Weight (g)	0.10	0.08	0.08	0.13	0.22	0.14	0.44	0.32	0.57	0.36	0.46	0.18	0.34	0.22	2.21	1.43
Food Item	Percentage of Weight (Percentage of Occurrence)															
PLANT	94(100)	87(100)	75(93)	72(100)	94(100)	93(95)	97(100)	93(97)	97(100)	97(100)	98(100)	93(100)	91(98)	98(100)	96(99)	95(100)
Sunflowers	71(100)	46(70)	52(73)	40(100)	72(87)	69(86)	67(88)	59(81)	73(96)	56(90)	70(95)	40(77)	60(94)	40(100)	69(93)	57(86)
Corn		3(10)			1(3)		9(16)	<1(6)	2(4)	2(6)	<1(1)		<1(1)		3(4)	1(4)
Other crops[a]		4(10)	<1(7)			<1(5)	7(20)	8(20)	4(17)	2(14)	3(9)	8(9)	3(12)	12(33)	4(13)	5(16)
Foxtail (*Setaria* spp.)	22(50)	34(60)	23(40)	32(50)	21(47)	22(47)	13(52)	25(78)	15(69)	36(77)	22(68)	44(83)	25(78)	46(78)	18(65)	31(72)
Incidental and unidentified seeds	1(6)				<1(1)	2(14)	<1(7)	<1(3)	3(9)	<1(10)	3(14)	<1(79)	3(18)		2(11)	1(7)
ANIMAL	6(50)	13(60)	25(73)	28(50)	6(53)	7(43)	3(48)	7(61)	3(72)	3(66)	2(68)	7(87)	9(67)	2(44)	4(64)	5(63)
GRIT[b]	(19)		(21)		(37)	(12)	(22)	(32)	(47)	(34)	(54)	(26)	(43)	(22)	(41)	(26)

[a]Includes Wheat, Barley, Oats, and Proso Millet
[b]Grit not included in food weight

TABLE 2. Percentage of occurrence of animals in esophagi of male and female (combined) Red-winged Blackbirds collected during 1979[a] in sunflower fields and corn fields in southwestern Cass County, North Dakota.

	Time Period									
	12 August–8 September		9 September–22 September		23 September–6 October		7 October–20 October		Totals	
Habitat	Corn	Sunflower	Corn	Sunflower	Corn	Sunflower	Corn	Sunflower	Corn	Sunflower
Number of Birds	16	24	48	60	66	138	62	99	192	321
Taxon	Percentage of Occurrence									
Hemiptera										
(Miscellaneous)	25	4	13	6	6	7	9	9	10	8
Miridae		9	19	7	6	5	8	2	9	5
Nabidae[b]			2	3	6	2	8	3	5	2
Homoptera										
(Miscellaneous)		8	23	8	18	13	6	12	14	11
Aphididae	56	9	20	8	24	15	23	24	26	16
Cicadellidae and Cercopidae	6	8	23	10	29	14	17	13	22	13
Neuroptera										
Chrysopidae[b]	25	12	33	10	15	4	13	4	20	6
Lepidoptera		9	15	8	9	11	6	10	9	10
Diptera	18	4	11	3	9	4	8	3	10	4
Coleoptera										
(Miscellaneous)	12	21	21	20	5	22	18	16	14	20
Curculionidae Larvae		4	2	5	5	27	3	19	3	18
Hymenoptera[b]		8	2	5	14	1	2	1	5	2
Arachnida[b]	12	4	23	23	15	9	16	9	17	7
Miscellaneous and Unidentified	12		2		5		3	3	4	1

[a] Major taxonomic categories were only identified in 1979
[b] Beneficial insects

TABLE 3. Percentage of weight and percentage of occurrence of food items in the esophagi of Red-winged Blackbirds collected in corn fields during 1979 and 1980 in southwestern Cass County, North Dakota.

	Time Period											
	12 August– 26 August		26 August– 8 September		9 September– 22 September		23 September– 6 October		7 October– 20 October		Totals	
Sex	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Number of birds	15	21	25	16	95	54	87	90	84	61	306	242
Mean Food Weight (g)	0.17	0.14	0.32	0.41	0.45	0.20	0.44	0.35	0.33	0.29	1.71	1.39
Food Item	Percentage of Weight (Percentage of Occurrence)											
PLANT	82(100)	82(95)	87(96)	94(100)	96(100)	92(100)	98(100)	98(100)	98(100)	95(98)	96(99)	95(99)
Corn	15(27)	3(5)	52(64)	7(38)	54(84)	20(41)	47(67)	20(47)	21(40)	10(33)	45(62)	16(38)
Sunflower	7(20)	<1(9)	1(12)	1(6)	3(6)	12(20)	12(20)	3(11)	21(38)	9(18)	8(20)	6(15)
Other crops[a]		7(14)	1(4)		<1(1)	<1(2)	<1(2)	1(2)	8(20)	8(18)	2(8)	3(14)
Foxtail (*Setaria* spp.)	60(73)	71(86)	33(56)	86(94)	38(75)	58(89)	38(74)	72(89)	46(79)	66(87)	40(81)	69(89)
Incidental and unidentified seeds			<1(4)		1(15)	2(13)	1(5)	2(7)	2(14)	2(11)	1(13)	1(9)
ANIMAL	18(43)	18(76)	13(56)	6(81)	4(68)	8(64)	2(61)	2(56)	2(44)	5(56)	4(57)	5(62)
GRIT[b]	(7)	(23)	(12)	(6)	(22)	(13)	(32)	(18)	(21)	(10)	(23)	(14)

[a]Includes Wheat, Barley, Oats, and Proso Millet
[b]Grit not included in food weight

This study indicated that both sexes consumed higher proportions of sunflower in sunflower fields than they did corn in corn fields. Males used 12 % more sunflower and 29 % more corn than did females. The percentage of sunflower in the male diets remained about the same throughout the sample period, whereas the percentage of sunflower in the female diets decreased as the sunflower seeds matured. In comparison, the proportion of corn in both the male and female diets decreased as the corn hardened.

Those differences may be related to the relative availability of sunflower and corn and to morphological and behavioral differences between the males and females. Corn is protected by husks, and after the seeds mature becomes difficult to remove and consume (Dolbeer 1980). In contrast, sunflower seeds are unprotected, easy to remove from the head, and as they mature become only slightly more difficult for the birds to shell and obtain the kernel. Unlike corn, sunflower heads are susceptible to seed loss due to wind and bird activity, particularly after some seeds are removed. Hence, a large number of sunflower seeds fall to the ground.

We observed Red-winged Blackbird feeding behavior in sunflower fields and in enclosed sunflower plots. Males appeared to spend more time removing seeds from the heads and less time foraging on the ground than the females. Similar differences in feeding behavior might occur in corn fields, but the females would not encounter corn on the ground as often as they do sunflower seeds.

The males' larger size and larger bill (Orians 1961) may enable them to slit the husks of the corn and handle the dry kernels more effectively than can the females. Larger size may be less advantage with sunflowers, where females have relatively easy access to the seeds in the head and on the ground and may be able to shell the seeds almost as readily as do the males.

We concluded that males were largely responsible for damage in sunflower fields and corn fields, although females had the potential to cause a significant amount of damage to sunflower. We do not know, however, what portion of the sunflower in female diets was waste grain taken on the ground. Further studies are needed to assess the depredation potential of females in sunflower fields.

In August and early September insects made up approximately 14 % of the diet of Red-winged Blackbirds in both sunflower fields and corn fields, but their importance in the birds' diets decreased as the season progressed. The possible economic benefits of Red-winged Blackbirds preying on noxious insects has intrigued many authors (Hintz and Dyer 1970; McNicol et al. 1982; Bendell and Weatherhead 1982). A high percentage of noxious insects in the birds' diets (Robertson et al. 1978; McNicol et al. 1982) and a reported population reduction of European Corn Borers (*Ostrinia nubilalis*) due to predation by Red-winged Blackbirds (Bendell and Weatherhead 1982) lend credence to this idea. On the other hand, insects may attract the birds to the fields before they begin feeding on the crop itself (Dolbeer 1980; Woronecki et al. 1981), thus offsetting any initial economic benefits with increased crop damage later in the year.

In our study, noxious insects occurred more often in the Red-winged Blackbirds' diets than did beneficial insects (predators) (Table 2). As prey species (noxious insects) usually outnumber predatory species (beneficial insects) (Krebs 1978), we would expect that, given equal availability, the birds would take more of the noxious insects than of their predators. That occurred with the aphidlions and aphids, where a predator-prey relationship may have existed (Borror et al. 1976). Similar relationships may exist with other beneficial and noxious insects. We suggest that predator-prey interactions among the insects should be considered when the economic benefits of insect feeding by Red-winged Blackbirds are investigated.

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Notes

Vestigial Wing Claws on Great Gray Owls, *Strix nebulosa*

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Nero, Robert W., and Steven L. Loch. 1984. Vestigial wing claws on Great Gray Owls, *Strix nebulosa*. Canadian Field-Naturalist 98(1): 45–46.

Great Gray Owls, *Strix nebulosa*, were found to have vestigial wing claws on digits II and III, both as juveniles and adults. Small claws on juveniles are common but often disappear by adulthood. Claws are present in some adults, in a few cases reaching lengths exceeded only by the wing claws of New World condors (*Gymnogyps, Vultur*). The claws have no apparent function.

Key Words: Great Gray Owl, *Strix nebulosa*, vestigial wing claws.

Wing claws on birds are vestigial and non-functional; the Hoatzin (*Opisthocomus cristatus*) (Pycraft 1903) and African Finfoot (*Podica senegalensis*) (Percy 1963), which use the wing claws for climbing, are exceptions. The occurrence of wing claws was studied by Fisher (1940) who examined 2004 specimens of 227 (mostly North American) genera. He found that alular claws were rather common, occurring in 14 of 21 orders examined. Claws on digit III were less common and occurred only in birds which also possessed alular claws. Such claws were found frequently in natal Anseriformes, and were present but uncommon in four other orders. Fisher found small ($\leqslant$ 1.5 mm) alular claws on two of four strigiform genera, and claws on digit III on natal *Otus*, but he did not examine owls of the genus *Strix*. The occurrence of wing claws on Great Gray Owls (*Strix nebulosa*) is reported here.

The senior author first observed alular claws on Great Gray Owls while examining an injured owl in September 1979 (Figure 1). During the next four winters about three-quarters of 109 owls handled for banding and approximately 20 dead owls were examined for alular claws. Claws were found by probing the distal region of the alular phalanx. Of approximately 50 adults examined, 9 (18%) possessed claws on the alula, and 6 of 35 immatures (17%) possessed such claws. Claws on adults were less than 1 mm in diameter and ranged in length from 4 to 16.5 mm ($\bar{x}$ = 9.5, n = 13). On any one bird (with one exception), length varied only slightly ($\leqslant$ 25%). The claws (n = 12) on immatures were all less than 5 mm in length. The frequency represents minimum occurrence as some claws likely were overlooked. This was especially so for immatures as their claws were shorter. Also, claws found were rigid and firmly attached; those not having such characteristics likely were missed.

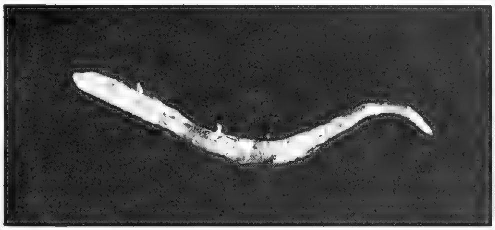

FIGURE 1. Great Gray Owl wing claw; 16.5 mm in length (chord). This is the largest claw thus far observed in this species. Note that it is atypical, i.e., twisted rather than curved.

Here we refer to digits II and II rather than digits I and II. Independent studies by Montagna (1945) and Holmgren (1955) indicated that the thumb and little finger were lost in birds, and that phalanges of digits II, III, and IV remain (Marshall 1960).

Claws on digit III were usually not looked for; 3 dead immature owls were carefully examined and minute claws were found on that digit. Nestlings were examined for wing claws in the summer of 1980. Claws were observed by parting and sometimes wetting the feathers at the distal ends of digits II and III of one wing. Eight of 8 and 6 of 9 bore claws on digit II (100%) and digit III (67%) respectively. All claws were less than 4 mm in length.

These data suggest that most Great Gray Owls bear wing claws when young, but many are lost, for reasons unknown, as the owl matures. This is possibly a consequence of the degenerative nature of the claw-producing tissues. Also, claws may be lost owing to abrasion and other factors. In some birds the alular claws persist and grow and may become relatively large. In Fisher's (1940) report, only the claws of New

World condors (*Gymnogyps, Vultur*) exceeded the greatest lengths reported here.

Thirteen alular claws removed from adults provided a basis for their description. The claws were embedded in the flesh on the dorsal surface of the distal extremity of the phalanx. The claws appeared not to articulate with or be reinforced by the phalanx, in contrast to the situation with normal claws (on feet of birds). Likewise, claws were embedded in the flesh at the terminal phalanx of digit III. Claws usually grew parallel to adjacent feathers and curved toward the ventral surface of the wing. Some claws, especially larger ones, tended to project anteriorly and to twist rather than curve.

The claws consisted of a hard, dense (though partly hollow) keratinized body covered in part or more often in total with a layered coating of soft, white, opaque material (Figure 2). The claws of nestlings and of most adults were entirely covered. Only remnants of the coating were adhering to the base of two other claws, and in three claws the coating was entirely lacking, apparently the result of abrasion. The coating appeared as a series of numerous overlapping layers which were easily removed, breaking off in flakes which readily crumbled to powder.

With the coating removed, the horny surface of the claw appeared a translucent blackish or gray. Fine parallel striations encircled the claw, and occasional abrupt changes in diameter caused the claw to appear pinched or restricted; those aspects were apparently growth-related.

The base of each claw was hollow and appeared as a membranous papery tube. The mid-section or stem of the claw had a round or more often flattened, sometimes slightly indented, ovoid cross-section. The tip of the claw was usually pointed and roughly triangular in cross-section. In two claws the tip was more complex than in the others, consisting of a central pointed portion with an attached piece on both sides.

Under magnification the claw appeared as a delicate tubular structure. In one claw a minute duct coursed its entire length; likewise, in another a ropy structure existed. In one claw there was an obvious pointed tip and tubular body protruding from inside another, not unlike the two claws described above. Somewhat similarly, a series of pointed tubes within tubes was observed when wing claws from a Red-winged Blackbird were dissected (Nero 1957).

Although perhaps only a trivial feature, the presence of wing claws in Great Gray Owls raises some fundamental evolutionary questions. Presumably the presence of these atavistic wing claws has caused no particular selective disadvantage. Perhaps this may be the explanation for their persistence over the great period of time since birds evolved from reptiles.

FIGURE 2. Great Gray Owl wing claw; 11.0 mm in length (chord).

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Dark-eyed Junco, *Junco hyemalis,* Nest Usurped by Pacific Jumping Mouse, *Zapus trinotatus*

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Smith, Kimberly G. 1984. Dark-eyed Junco, *Junco hyemalis,* nest usurped by Pacific Jumping Mouse, *Zapus trinotatus.* Canadian Field-Naturalist 98(1): 47–48.

A dark-eyed Junco (*Junco hyemalis*) nest, which contained four eggs upon discovery, was usurped by a Pacific Jumping Mouse (*Zapus trinotatus*), which incorporated the junco nest into its nest. Scattered egg fragments at the nest, along with results of feeding trials with captive mice, suggest that the Pacific Jumping Mouse is a potential predator of bird eggs.

Key Words: Dark-eyed Junco, *Junco hyemalis,* Pacific Jumping Mouse, *Zapus trinotatus,* nest predation, food habits.

Although rarely apprehended in the act, small mammals are frequently implicated as nest predators of ground-nesting birds (e.g. Williams 1900, Maxson and Oring 1978, Smith and Andersen 1982). Small mammals also commonly live in nest cavities created by birds in trees, but few reports exist of small mammals using open cup-shaped nests of birds. Thus, the following observations at the nest of a Dark-eyed (Oregon) Junco (*Junco hyemalis*) are of interest, since the apparent nest predator remained, having incorporated the junco nest into its own.

I flushed a female junco from a nest on 29 June 1982 at 1100 in a moist subalpine clear-cut 15 km southeast of Randle, Lewis Co., Washington. The nest, which contained four eggs, was on the ground, hidden under a *Vaccinium* bush, and was a typical junco nest: an open cup made of dried grasses and leaves woven together, lined with several strands of coarse dark mammal hair (probably American Elk, *Cervus elaphus*).

I revisited the nest at 1210 on 7 July 1982 and discovered that the junco nest had been modified to the nest of a Pacific jumping mouse (*Zapus trinotatus*). It was a typical *Z. trinotatus* nest (e.g. Maser et al. 1981), consisting of a dome of loosely woven grasses with an entrance hole on the side, with the junco nest constituting the floor. Several egg fragments were scattered around the entrance hole, suggesting that a small rodent had eaten the junco eggs, since small rodents commonly do not eat the entire egg shell when depredating a nest (personal observation; Maxson and Oring 1978). An adult *Z. trinotatus* emerged from the nest and scurried off into nearby vegetation. I left the nest, but returned at 1220, and again an adult jumping mouse emerged from the nest. No animal emerged from the nest on the mornings of 8 July through 12 July, and the nest was empty on the afternoon of 15 July 1982.

The evidence suggests that jumping mice are (heretofore unrecognized) predators of bird eggs; bird eggs have not been mentioned in *Zapus* food studies (see Jones et al. 1978). Members of the genus *Zapus* are usually considered vegetarians (e.g. Maser et al. 1981) or "granivorus omnivores" (Barry 1976), that prefer grass seeds and fungi (*Endogone*) to animal material (Jones et al. 1978). Jumping mice are capable of eating a wide variety of insects and mollusks (Quimby 1951) and have been captured in a trap baited with a fresh fish head (Svihla and Svihla 1933).

We performed two experiments, similar to those of Quimby (1951), to test the reaction of *Z. trinotatus* to junco eggs. We placed a junco egg which was about 23 days old in a cage with a male and a pregnant female *Z. trinotatus* that we had in captivity for several days. No other food was present. The egg was eaten within three hours. We later offered the male a junco egg which was about eight days old, but with rat chow *ad libitum.* The egg remained uneaten for six days at which time it was removed.

The results demonstrate that *Z. trinotatus* will eat junco eggs, but that eggs probably are not a preferred food. Whitaker (1963) suggested that *Z. hudsonicus* diets are determined by availability, not preference, and Vaughan and Weil (1980) pointed out that, during periods of low seed availability or abundance, arthropods may be an important component of the *Zapus princeps* diet, so that animal material is more important in the early part of the breeding season (Whitaker 1963). My observations are consistent with these conclusions: the eggs disappeared early in the season during a cold and rainy period (25 June-4 July) in a summer of late snowmelt.

Acknowledgments

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Northern Wheatears, *Oenanthe oenanthe,* on Axel Heiberg and Ellesmere Islands, Northwest Territories

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Boothroyd, Peter N. 1984. Northern Wheatears, *Oenanthe oenanthe,* on Axel Heiberg and Ellesmere islands, Northwest Territories. Canadian Field-Naturalist 98(1): 48–49.

Occurrence of the Northern Wheatear (*Oenanthe oenanthe*) on Axel Heiberg Island, Northwest Territories, is documented for the first time, with an indication of possible breeding. A probable nesting record for the species on Ellesmere Island is also reported.

Key Words: Northern Wheatear, *Oenanthe oenanthe,* Axel Heiberg Island, Ellesmere Island.

In July 1980, while conducting a natural resource inventory of eastern Axel Heiberg Island for Parks Canada, I observed Northern Wheatears (*Oenanthe oenanthe*) on three occasions. Although the species has been reported on Ellesmere Island (Parmelee and MacDonald 1960, Godfrey 1966), no previous records are known on Axel Heiberg Island. Neither Macpherson (1963) nor G. Waterton and I. Waterton (Canadian Wildlife Service, unpublished manuscript, Ottawa, CWSC 1481) reported the occurrence of the species during their visits to the latter island.

On 21 July, I saw a female at 79° 05′N, 87° 10′W, about 410 m above sea level (asl) in a creek valley between unvegetated talus slopes. The bird hopped around within 20 m of where I was sitting, permitting prolonged viewing with 8 X 40 binoculars, and positive identification. Later that day, two pairs were seen making short flights interspersed with brief stops on the rocky slopes adjacent to a well-vegetated meadow area about 30 km northeast of the previous sighting. The fact that the birds occurred in pairs suggested breeding, although no distraction or territorial defence displays or other evidence of breeding were noticed. Other sightings of the species (both sexes) were made at a third location (79° 20′N, 86° 38′W) on 23 July in the vicinity of sandstone formations situated approximately 15 km northwest of the second sighting.

On 22 July, a nest, believed to be that of a Northern Wheatear, was located deep within a fissure in the side of a limestone outcrop at Hare Fiord, Ellesmere Island (80° 49′N, 85° 55′W, elevation 455 m asl). A Northern Wheatear, flushing from the outcrop in the vicinity of the fissure, prompted the search for and discovery of the nest. The fissure was too narrow, and the nest placed too far back, to permit examination of the contents. However, the absence of Snow Buntings (*Plectrophenax nivalis*) in the area at the time the nest was discovered supported the belief that the nest belonged to a Northern Wheatear. The nest location

strongly resembled Northern Wheatear nest sites on Baffin Island described by Sutton and Parmelee (1954).

Although verification is required, it is likely that the Northern Wheatear breeds on Axel Heiberg Island. Many areas of elevated, rocky or boulder-strewn slopes and rock outcrops occur on the island. Such areas are the preferred breeding habitat of the species (Godfrey 1966).

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Observations on Male Ruffed Grouse, *Bonasa umbellus*, Accompanying Brood

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Hoff, James G. 1984. Observations on male Ruffed Grouse, *Bonasa umbellus*, accompanying brood. Canadian Field-Naturalist 98(1): 49–50.

A male Ruffed Grouse (*Bonasa umbellus*) was sighted four times over a 36-h period with a female and her 7-10 d brood.

Key Words: Ruffed Grouse, *Bonasa umbellus*, brood behavior, Maine.

Occasionally male Ruffed Grouse (*Bonasa umbellus*) flush near or even directly with a female and her chicks, but the circumstance has not been reported twice for the same brood. Females are thought to leave the males after they have been fertilized and begin their nesting activities (Johnsgard 1975). This note reports an adult male as an associate of a Ruffed Grouse brood over a two day period.

Short (1895) and Forbush (1907) reported rare clucking or strutting from a second adult bird with a grouse brood. Bump et al. (1947) concluded that such occurrences are rare and that the second bird may be a female which either lost her brood or merged it with another. In over 35 years of Ruffed Grouse observations, I have rarely flushed two adult birds with a young brood. While camping in Dexter, Penobscot Co., Maine, I had an opportunity to study an unusual grouse group.

The sequence of events was observed from early morning 21 June to midafternoon 22 June 1982. My observations were made from a small cabin on a ridge in a partially cleared 500 m^2 area. The prominent trees are Bigtooth Aspen (*Populus grandidentata*), Paper Birch (*Betula papyrifera*), White Ash (*Fraxinus americana*) and Common Apple (*Malus pumila*). The area abounds with overgrown abandoned farms, tote roads and old apple orchards.

Two adult Ruffed Grouse moved into the clearing with a brood of seven or eight chicks. Since both adults were in view, there was a suitable basis for comparison. One, presumably the male, had a longer tail and its legs appeared longer. The overall color pattern of the male was bolder and more clearly defined than the diffuse color pattern of the female, which seemed to blend with the background. The male had a clearly defined band of dark color in the front half of the neck. Overall, the male looked heavier and more solidly built than the female.

The female was most vocal and on seeing me gave the familiar broken-wing display. She was the first to flush, and the young usually froze briefly and then flushed at a distance of approximately 5 m. The male occasionally gave a low hissing or clucking sound and once fluttered his wings before he flushed. The female remained more apprehensive than the male, on each return visit she showed less brood stress behavior; that is, she was less vocal and not as quick to flush or feign injury. In the first two sightings the female ruffled her feathers and half-spread her wings and uttered a hiss and squeal before flushing. In subsequent visits the

behavior pattern was similar but briefer. The male, which was the most conspicuous bird, always flushed last, and seemed to be occupied with feeding. Wild strawberries (*Fragaria*) were plentiful in the area and were the major food consumed. From their plumage and flight ability, I estimated the chicks to have been 7-10 days old. They fed continuously, mostly on carpenter ants (*Camponotus herculeanus*). Over a 36-h period the group visited the area four times. I watched them for about 30 min in all.

I am confident that I viewed the same birds on each visitation. The male was a large, basically gray individual with a clear gray tail with a well developed black subterminal band. He moved with the brood although usually 10-20 m away. I do not know whether the combination of choice foods (Bump et al. 1947) influenced the behavior and the male's presence, but I am certain the male was a member of that Ruffed Grouse group.

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Food Habits of Bobcats, *Lynx rufus*, in Nova Scotia

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Mills, John K. 1984. Food habits of Bobcats, *Lynx rufus*, in Nova Scotia. Canadian Field-Naturalist 98(1): 50–51.

Forty-seven scats and 113 stomachs of Bobcat (*Lynx rufus*) were collected during the fall and winter of 1980-81 and examined for food remains. Snowshoe hare (*Lepus americanus*) and Red Squirrel (*Tamiascurius hudsonicus*) occurred most frequently in scats, while hare and White-tail Deer (*Odocoileus virginianus*) were most common in stomachs. One instance each of consumption of Skunk (*Mephitis mephitis*) and Otter (*Lontra canadensis*) is recorded.

Key Words: Bobcats, *Lynx rufus*, food habits, Nova Scotia.

To date, relatively few investigations into the food habits of Bobcat (*Lynx rufus*) in Nova Scotia have been undertaken. Lewis (1961), Yescott (1967), and Parker (1983) all examined various aspects of bobcat food habits. Lewis examined scats and stomachs from mainland Nova Scotia; Yescott concentrated on specimens from an area in the southeast of Halifax county and Parker from Cape Breton Island. Although the literature contains a number of references, the majority of Bobcat food habits studies have been in the United States. The Bobcat is distributed over the whole province (excepting the Cape Breton Highlands) and has been subject to increased trapping pressure during the past few years.

Scats were collected in the Tobeatic Wildlife Management Unit, Nova Scotia, 1 September through 30 November 1980. The stomachs were from animals trapped, snared and shot during the open season (1 November to 28 February). For this study, stomachs from Colchester, Cumberland, Annapolis, Lunenburg, Kings and Queens counties were examined on the assumption that these six counties were geophysically representative of mainland Nova Scotia.

Scats were dried, broken apart by hand, and put through a fine meshed sieve to separate food remains. They were then placed in a tray and food items (hairs, bones, feathers, teeth) were separated and identified. A 10 power (10X) magnifying lamp was used to aid in macroscopic examination.

Stomachs were frozen after removal from carcasses and examined later. Contents were thawed and washed in a fine meshed sieve, separated, and identified, using the same method as for scats. A skull key, hair key and specimens from the Acadia University Museum were used to aid in identification of food items. Materials used as bait for trapped cats were omitted from the results. Empty stomachs and those containing only vegetation were not included. The occurrence of the food items were calculated from stomachs containing food items only.

This study focussed on the occurrence of different food items, therefore only frequency and percent are

expressed. Since stomach contents were not measured by volume, the importance of a food item can be expressed only by its occurrence and not in terms of calorific intake.

Snowshoe Hare (*Lepus americanus*) was the primary food item occurring in 74.5 % of the scats and 74.3 % of the stomachs. Lewis (1961), found Snowshoe Hare occurrence in 53 % of stomachs in a three year average, 1959-1961, and Parker (1983) found hares occurring in 92 % of the stomachs in the winter of 1977-78, 83 % during the winter of 1978-79 and 84 % for 1979-80 on Cape Breton Island, Nova Scotia. Yescott (1967) reports hare findings of 69.9 % in scats and digestive tracts and 54.5 % in digestive tracts (two separate instances). In this study Red Squirrel (*Tamiascurius hudsonicus*) was the second highest food item in the scats, occurring at 17.0 %, and White-tailed Deer (*Odocoileus virginianus*) were second in importance in stomachs at 15.7 %. Small mammals, such as the Meadow Vole (*Microtus pennsylvanicus*), Red-backed Vole (*Clethrionomys gapperi*), Deer Mouse (*Peromyscus maniculatus*) and Masked Shrew (*Sorex cinereus*), all made up part of the Bobcat diet. (Tables 1 and 2).

Herbaceous and woody vegetation was evident in both scat (35.4 %) and stomach (58.0 %) samples. This material, while not a food item, was probably ingested while the Bobcat was held alive in foot-traps or occurred from eating prey on the ground.

TABLE 1. Food items found in 47 Bobcat scats.

Prey Species	Frequency	Percent
Snowshoe Hare *Lepus americanus*	35	74.5
Red Squirrel *Tamiascurius hudsonicus*	8	17.0
White-tail Deer *Odocoileus virginianus*	7	14.9
Red-backed Vole *Clethrionomys gapperi*	3	6.4
Meadow Vole *Microtus pennsylvanicus*	4	8.5
Deer Mouse *Peromyscus maniculatus*	1	2.1
Unidentified mammal	3	6.4
Unidentified bird	4	8.5

TABLE 2. Food items found in 70 Bobcat stomachs.[1]

Prey Species	Frequency	Percent
Snowshoe Hare *Lepus americanus*	52	74.3
White-tail Deer *Odocoileus virginianus*	11	15.7
Meadow Vole *Microtus pennsylvanicus*	6	8.6
Red Squirrel *Tamiascurius hudsonicus*	3	4.3
Red-backed Vole *Clethrionomys gapperi*	4	5.7
Masked Shrew *Sorex cinereus*	3	4.3
Porcupine *Erithizon dorsatum*	2	2.9
Skunk *Mephitis mephitis*	1	1.4
Otter *Lontra canadensis*	1	1.4
Ruffed Grouse *Bonasa umbellus*	1	1.4
Golden Crowned Kinglet *Regulus satrapa*	1	1.4
Unidentified mammal	4	5.7
Unidentified bird	2	2.9
Unknown and miscellaneous	2	2.9

[1]An additional 43 stomachs were empty or contained vegetation only and not included in the calculations.

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How to Distinguish First-Year Murres, *Uria* spp., from Older Birds in Winter

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Gaston, A. J. 1984. How to distinguish first-year murres, *Uria* spp., from older birds in winter. Canadian Field-Naturalist 98(1): 52–55.

I examined breeding season and winter specimens of Common and Thick-billed Murres to find a method for distinguishing first-year from older birds. The presence of well-developed supra-orbital ridges appears to be characteristic of older birds, which in the case of Thick-billed Murres also have larger bill dimensions. A method for aging Thick-billed Murres on the basis of bill measurements is given.

Key Words: Murres, *Uria lomvia, Uria aalge,* age determination, skull.

Fledgling Common Murres, *Uria aalge*, and Thick-billed Murres, *Uria lomvia*, leave their breeding colonies at only 20-25 % of adult weight (Tuck 1961; Gaston and Nettleship 1981). Little is known about their growth in the period following their departure, but by the time they arrive on their wintering grounds 3-4 months later they have reached more-or-less adult size. Differences in wing, bill and tarsus measurements between adult and first-year Thick-billed Murres were noted by Storer (1952), but the measurements he presented do not allow individual birds to be aged precisely because of a wide area of overlap. Also, Storer indicated that he distinguished first-year murres on the basis of their measurements; a somewhat circular procedure.

While examining a series of murres shot in Newfoundland in winter, I noticed variation among specimens in the extent to which the supra-orbital ridges of the skull were developed. This appeared a likely character for aging the specimens, and I therefore tried to compare the variation in the development of the supra-orbital ridge to other age-related phenomena.

I examined the following samples of Thick-billed Murres:

(1) 19 collected near Twillingate, NE Newfoundland, in November 1981;
(2) 52 from Trinity Bay, SE Newfoundland, collected in February 1981 (20) and February 1983 (32);
(3) Three, including a banded bird known to be in its first winter, collected in February 1982 in Placentia Bay, Newfoundland;
(4) Additional heads without bodies from Trinity Bay in February 1981 (18) and December 1982 (32) and from Twillingate in November 1981 (6);
(5) 40 collected near a breeding colony at Digges Island, N.W.T., in summer, of which all but four had large brood-patches indicating that they were breeding.

The supra-orbital ridges on all of the birds from Digges Island were well developed, thickened at the outer margin and each pierced by two prominent fossae (Figure 1A). All breeders were probably at least four years old (by analogy with Common Murres; Birkhead and Hudson 1977). By contrast, 27 out of 111 Thick-billed Murres examined from Newfoundland, including one known first-year bird, showed no development of the supra-orbital ridges (Figure 1B). Comparison of measurements showed that the birds without supra-orbital ridges were significantly smaller than those with supra-orbital ridges in all measurements (Table 1).

I examined this phenomenon also in Common Murres by taking x-ray photographs of two 13-year-old and two first-year (live) birds from the Montreal Aquarium. I also dissected one dead first-year Common Murre supplied by the aquarium. All three first-year birds showed incomplete ossification of the supra-orbital ridges, whereas the two adults had prominent ridges. Ten adult Common Murres from Newfoundland breeding colonies in the National Museums of Canada collection all had prominent supra-orbital ridges.

Only two of the Thick-billed Murres examined by dissection were clearly intermediate between the two types illustrated in Figure 1. The scarcity of intermediates among either summer or winter samples suggests that developement of the supra-orbital ridges proceeds quite rapidly, most of it presumably taking place between the end of the first winter and the start of the second. Hence birds without any development of supra-orbital ridges can probably be treated as first-years. In the Razorbill (*Alca torda*), where first-winter birds can be identified by a lack of grooves on the bill, no first-winter birds had supra-orbital ridges, but the majority of older birds did in a sample of 107 (P. Hope-Jones *in litt.*).

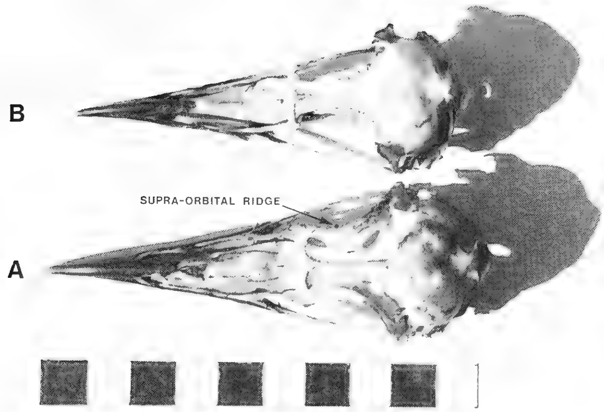

FIGURE 1. Skulls of Thick-billed Murres collected in Trinity Bay, Newfoundland, in February 1981; (A) adult type, (B) first-year type.

TABLE 1. Differences between "first-year" and "older" Thick-billed Murres collected in February and November (for aging criterion, see text).

Measurement		First Year			Adult			t	P
		$\bar{x}$	SD	N	$\bar{x}$	SD	N		
Weight (g)	NOV	915.6	106.3	15	1000.2	77.0	4	1.79	NS
	FEB	817.5	49.3	8	951.9	69.8	45	5.20	< 0.001
Wing (mm)	NOV	206.5	7.7	15	218.5	3.7	4	2.98	0.008
	FEB	205.5	5.6	8	216.2	5.5	45	5.03	< 0.001
Bill:									
line[1] (mm)	NOV	52.3	3.2	14	57.4	2.0	4	2.99	0.009
	FEB	50.6	1.4	7	54.2	2.0	44	4.88	< 0.001
depth[1] (mm)	NOV	11.0	0.6	14	13.2	0.9	4	6.13	0.001
	FEB	11.1	0.8	9	13.0	0.5	43	8.80	< 0.001
culmen (mm)	NOV	31.0	3.2	14	34.8	2.5	4	2.16	< 0.047
	FEB	31.4	3.1	10	34.1	1.9	44	3.60	< 0.001
nostril[1] (mm)	NOV	25.0	1.7	14	28.0	2.1	4	2.99	0.009
	FEB	25.7	2.6	10	28.6	1.1	44	5.66	< 0.001

[1]Measured as follows: distance from proximal end of white line above gape to bill tip (line); depth just proximal to notch in lower mandible; distance from distal edge of external nares to bill tip (nostril).

Other criteria which seem closely related to the presence or absence of supra-orbital ridges in murres are:

(1) the colour and texture of the feet, which are softer and paler in birds without supra-orbital ridges than in others;
(2) the appearance of the greater coverts, some of which are worn and tinged with brown in first-year Common Murres through retention of juvenile feathers (Kuschert et al. 1981); and
(3) in Thick-billed Murres the flexibility of the lower mandible, which will bend if the body is held only by the beak in first-year birds, while remaining rigid in adults.

The third character was demonstrated by murre hunters at Twillingate, Newfoundland, in November (R. I. Goudie, CWS, personal communication). It appears to correlate well with the skull criterion for November birds.

Assuming that birds with supra-orbital ridges in winter are more than one year old and those without are first-winter birds, I examined the bill measurements of birds collected in winter to see what discrimination could be obtained from them for the two age classes. Bill depth proved to be the best single measurement, but a bivariate plot of bill depth against length from the anterior edge of the nostril to the bill tip further reduced the overlap (Figure 2, using only birds collected in February to allow for possible changes in bill dimensions over the winter). A canonical discriminant function analysis, incorporating all measurements in Table 1, did not improve the proportion discriminated correctly when both methods were applied to the sample of 32 birds collected in December 1982. Both methods correctly identified 30 out of 32 (94 %).

The timing of ossification of parts of the skull, particularly the frontal and parietal bones, has been used as a criterion for aging many species of passerine birds (Svensson 1975). However, the development of supra-orbital ridges has not been used previously as a criterion for age so far as I can discover. This area is

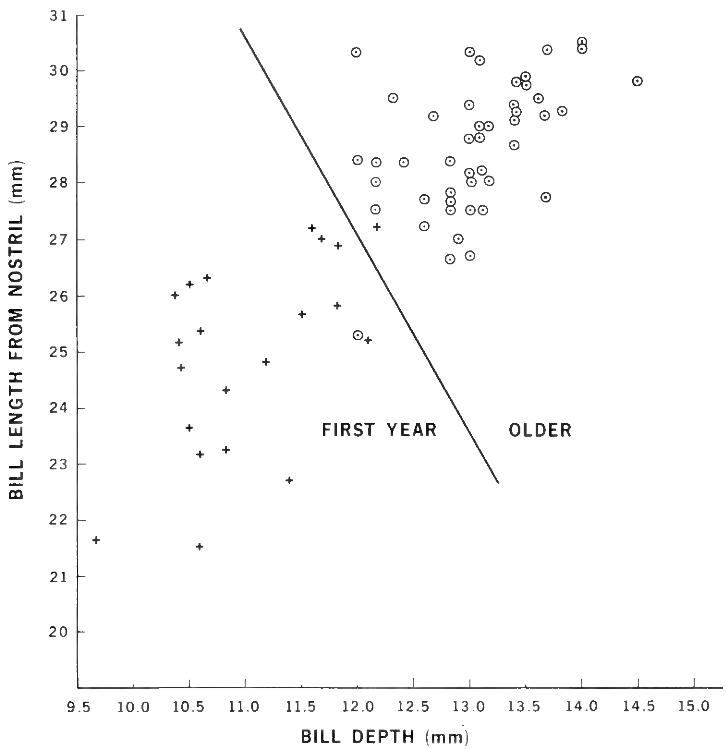

FIGURE 2. Scatter plot of bill depth against nostril length for Thick-billed Murres collected in Newfoundland in February.

complete soon after hatching in the case of the domestic fowl (*Gallus gallus*) (Jollie 1957), and *Uria* species seem to be unusual in delaying the ossification of this region.

Replicate measurements by several people suggest that the nostril to tip length can be more accurately measured than any of the other bill length measurements, which are all highly inter-correlated ($r > 0.67$). For a practical guide to age for Thick-billed Murres based on external measurements I therefore suggest a bivariate plot of nostril to tip length against bill depth.

Acknowledgments

Many thanks to Ian Goudie, John Piatt, Steve Wendt and Todd and Terry Woodman for assistance in obtaining the specimens from Newfoundland. David Noble helped to examine the specimens, and Graham Cooch and Hugh Boyd gave useful comments on the manuscript. Serge Parent and the staff of the Montreal Aquarium were very helpful in arranging for me to examine their captive birds and Dr. Jean-Luc Bureau took the X-ray photographs. Peter Hope-Jones supplied information on Razorbills. The drawing was provided by the Drafting Unit of Environment Canada.

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Unusual Damage Caused by Muskrats, *Ondatra zibethicus*

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Craven, Scott R. 1984. Unusual damage caused by Muskrats, *Ondatra zibethicus*. Canadian Field-Naturalist 98(1): 55–56.

Two cases of damage to wiring hoses, cables and tubing of a vehicle and of propane exploders (for Canada Goose dispersion) due to Muskrats are reported.

Key Words: Muskrats, *Ondatra zibethicus*, gnawing damage.

Rodents damage a wide range of inert or inedible materials. While this damage is widely recognized, the behavioral motivation has not been well established. The Norway Rat (*Rattus norvegicus*) and the Pocket Gopher (*Geomys bursarius*) frequently gnaw on hard objects, presumably to sharpen and maintain their continuously growing incisors (Howard 1953). The Porcupine (*Erethizon dorsatum*) gnaws on any object covered with a salty solution such as human perspiration or encrusted road salt (Jackson 1961). Porcupine behavior, and the rapid consumption of shed antlers by small mammals, suggests that these species are satisfying a need for certain minerals. Welker and King (1962) demonstrated the influence of novelty of both edible and inedible materials in the eating and gnawing behavior of laboratory rats. They suggest that rats keep in constant oral contact with a variety of stimuli in their environment, regardless of nutritive value. Thus there are at least three theories to explain rodent damage to inedible materials.

The Muskrat (*Ondatra zibethicus*) is a valuable furbearer but it also does considerable damage in some areas of its range. Errington (1938) described Muskrat damage to corn and other crops in Iowa. Several authors (Lynch et al. 1947; Beshears and Haugen 1953; Cook 1957; Erickson 1966; and Miller 1974) discussed damage resulting from the burrowing activity of Muskrats. In 1969, Miller estimated damage in the rice growing areas of Arkansas to approach $1 million annually. Miller (personal communication)

also noted gnawing damage to styrofoam flotation devices and flexible irrigation pipe. The Muskrat has not been a major problem in Wisconsin (Jackson 1961), and it is not among the 19 mammals mentioned by respondents to a survey of wildlife damage in Wisconsin (Craven, unpublished data). However, two instances of significant and unusual damage have been recently noted.

During the winter of 1979-80, a Muskrat caused extensive damage to hoses, wiring and cables in the engine compartment of a vehicle stored for the winter at Horicon National Wildlife Refuge (NWR), Mayville, Wisconsin. The damage rendered the vehicle inoperable. It was parked in a stand of mixed grasses and annual weeds approximately 0.5 m high. The nearest water was in a drainage ditch and a permanent pond on the periphery of Horicon Marsh, 50 m and 500 m, respectively, from the truck. A Muskrat was found dead and partially decomposed on the engine during the spring of 1980. The animal had apparently carried a small amount of vegetation and several cobs of corn into the engine compartment. Eleven cases of similar damage to vehicles caused by Yellow-bellied Marmots (*Marmota flaviventris*) in Sequoia National Park were widely reported by the national wire services in 1981.

During the fall of 1977, 365 propane exploders of the type commonly used in wildlife damage control were distributed throughout Horicon NWR to disperse large concentrations of Canada Geese (*Branta canadensis*). Each exploder was suspended from a wooden tripod. Whenever the exploder, or parts thereof, were close to or partially in contact with water, the rubber tubing connecting the propane tank to the firing chamber was gnawed and usually severed by Muskrats (C. Swanberg, personal communication). Such damage necessitated the removal of the exploder for repair. I suggest the observed damage to the vehicle was caused by gnawing behavior expressed on the only materials available, perhaps enhanced by encrusted road salt. In the case of the exploder damage, the novelty response described by Welker and King (1962) is an adequate explanation. Although novelty gnawing quickly subsided in laboratory rats, in the wild setting enough naive individuals are available to sustain the observed damage over an extended period.

I know of no other records of similar damage caused by Muskrats. Horicon NWR supports a large Muskrat population and the value of their pelts far exceeds the costs incurred from damage. During the 1979-80 and 1980-81 seasons, 52 543 and 48 205 Muskrats, worth a total of $644 000, were taken from 4-6000 ha of habitat on the refuge (D. Haugen, personal communication). Certainly no control program such as that undertaken in agricultural areas in the southern United States is justified. However, individuals should be aware of potential problems when using or storing farm machinery, research equipment, vehicles, or other devices and materials in or near Muskrat habitat.

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Fisher, *Martes pennanti,* Scent Marking Behaviour

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Pittaway, Ronald J. 1984. Fisher, *Martes pennanti,* scent marking behaviour. Canadian Field-Naturalist 98(1): 57.

Three observations of a male Fisher (*Martes pennanti*) marking a carcass of a White-tailed Deer (*Odocoileus virginianus*) with urine are described. The Fisher marked the carcass by spreading its hind legs and dragging its abdominal region against the carcass. Traces of urine were smeared on the carcass.

Key Words: Fisher, *Martes pennanti*, scent marking, Algonquin Park.

Observations on the scent marking behaviour of a male Fisher (*Martes pennanti*) were made in Algonquin Provincial Park, Ontario. A carcass of a White-tailed Deer (*Odocoileus virginianus*) attracted the Fisher to a window viewing area at the Park Museum. At night, an outside light illuminated the viewing area.

The Fisher uses urine to scent-mark the entrance to its den (Pittaway 1978). On 2 January 1980, a male Fisher which had been feeding on a White-tailed Deer carcass, marked it twice with urine between 1800h and 1830h. Both times marking was performed by the Fisher crawling foward over the carcass with its hind legs spread, allowing the genital region to be pressed and dragged against the carcass. Examination revealed small amounts of urine smeared on the carcass. R. D. Strickland (personal communication) made a similar observation of the same Fisher three days later. He described it as "straddling" the carcass with its hind legs spread apart and dragging its abdominal region over the carcass. Strickland also noted a trace of urine on the carcass. Powell (1982) examined Fisher tracks and signs of urine in winter; he found evidence that "Fishers sometimes walk over and apparently drag their bellies on small stumps or mounds of snow that protrude from the surface of the snow . . ." and "They usually urniate on the stump or the snow mound."

Martens (*Martes americana*) also drag their bellies across projecting objects, presumably to deposit scent from their abdominal glands for communication with conspecifics (Markley and Bassett 1942). The Fisher lacks obvious evidence of an abdominal scent gland found on the Wolverine (*Gulo gulo*) and the Marten (Hall 1926). Hall based his study on a gross examination of museum skins. C. W. Douglas (personal communication) has examined hundreds of Fishers caught by trappers and detected no suggestion of an abdominal gland. A histological examination of fresh material is needed to determine the presence or absence of this gland.

If the Fisher lacks the abdominal gland, it is possible that smearing urine onto objects performs a similar function as that of the abdominal gland found in Wolverines and Martens. Urination in combination with abdominal dragging to smear the urine onto objects appears to be an important form of marking behaviour and chemical communication in Fishers.

Acknowledgments

I am grateful to M. E. Buss, Biology Specialist, Leslie M. Frost Natural Resources Centre and E. M. Addison, Research Scientist, Ministry of Natural Resources, for reviewing the manuscript. I wish to thank R. D. Strickland for his observation of marking behaviour and C. W. Douglas for information about Fisher specimens. My thanks to L. K. Pittaway and M. L. Larose for their assistance.

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Range Extension of the Blackchin Shiner, *Notropis heterodon,* to Dauphin Lake, Manitoba

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Babaluk, John A., and Stephen M. Harbicht. 1984. Range extension of the Blackchin Shiner, *Notropis heterodon,* to Dauphin Lake, Manitoba. Canadian Field-Naturalist 98(1): 58–59.

Twenty-three Blackchin Shiners were collected from waters in the Dauphin Lake drainage system, Manitoba. This extends the northern limit of the documented range by approximately 400 km.

Key Words: Blackchin Shiner, *Notropis heterodon,* Dauphin Lake, Manitoba, range extension.

During the summer of 1982 a preliminary fisheries survey of Dauphin Lake, Manitoba (51° 17′N, 99° 48′W), and its associated rivers and streams provided several specimens identified as Blackchin Shiner, *Notropis heterodon.* Present distribution records for this species indicate that it does not occur in Manitoba (Scott and Crossman 1973) although Fedoruk (1974) suggested that the species might occur in southern Manitoba. Lee et al. (1980) state that the species has recently entered some of the headwaters of the Red River in Minnesota which is approximately 400 km southeast of Dauphin Lake. Dr. K. W. Stewart (personal communication) of the Department of Zoology, University of Manitoba, collected a number of specimens of Blackchin Shiner during the summer of 1982 from Kichie Manitou Lake (49° 39′N, 99° 18′W) in Spruce Woods Provincial Park in southwestern Manitoba. This location is approximately 180 km south of Dauphin Lake. These specimens are now part of the fish collection of the Department of Zoology, University of Manitoba, Winnipeg.

A total of twenty-three specimens of Blackchin Shiner were collected from waters in the Dauphin Lake drainage system during the summer of 1982. Ten specimens were collected on 10 August in beach seines on a sand bar in Dauphin Lake at the mouth of the Valley River (51° 22′N, 99° 55′W). Two specimens were collected on 13 August in the lake at the mouth of the Ochre River (51° 07′N, 99° 45′W). Six specimens were collected in beach seines or with electrofishing gear from a number of streams flowing into Dauphin Lake. Of these, one was collected on 28 June in the Turtle River (51° 04′N, 99° 32′W) approximately 14 km upstream from the mouth. Four specimens were collected on 20 June from Crooked Creek (51° 08′N, 99° 50′W) approximately 500 m upstream from the mouth, while one specimen was collected on 9 August from Mink Creek (51° 26′N, 99° 59′W) approximately 2 km from the mouth. Another five specimens were collected on 24 June from the Mossy River (51° 27′N, 99° 57′W), which connects Dauphin Lake to Lake Winnipegosis, approximately 1 km downstream from the lake.

Using the criteria outlined by Scott and Crossman (1973) for external description, colouration (noting the dark lateral band forming a zigzag pattern and extending onto the chin), and pharyngeal teeth counts (1, 4-4, 0; 1, 3-4, 1; 1, 3-4, 1 for three specimens examined) the specimens were identified as the Blackchin Shiner. One specimen has been placed in the National Museum of Natural Sciences, Ottawa (NMC 83–0136), and three specimens have been placed in the fish collection of the Department of Zoology, University of Manitoba, Winnipeg. The remaining specimens are in a fish collection at the Freshwater Institute, Winnipeg.

Acknowledgments

We thank B. Belcher and D. MacDonell for their assistance in collecting the specimens and Dr. B. Coad of the National Museum of Natural Sciences and R. A. Ratynski for their confirmation of our identifications. The collection of Blackchin Shiners from the Dauphin Lake area is incidental to studies undertaken relative to the Canada / Manitoba Fisheries Rehabilitation Pilot Program.

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Piping Plover, *Charadrius melodus*, at Lake Athabasca, Saskatchewan: A Significant Northward Range Extension

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Adam, Christopher I. G. 1984. Piping Plover, *Charadrius melodus*, at Lake Athabasca, Saskatchewan: a significant northward range extension. Canadian Field-Naturalist 98(1): 59–60.

Adult Piping Plovers, *Charadrius melodus*, with a recently hatched brood of four young were observed in northern Saskatchewan in July 1982, a northward extension of the known breeding range of this species by 685 km.

Key Words: Piping Plover, *Charadrius melodus*, Lake Athabasca, Saskatchewan, range extension.

Piping Plovers, *Charadrius melodus*, were observed with a brood of four young west of the mouth of the Archibald River, near Wolverine Point, Lake Athabasca, northern Saskatchewan, in the summer of 1982. That record constitutes a significant northward extension of the breeding range of this species. Because the species was not observed during earlier comprehensive studies in the Lake Athabasca area (Nero 1963), the occurrence is described in detail.

The Athabasca Sand Dunes along the south shore of Lake Athabasca are the northern exposures of the extensive Athabasca Formation (sandstone), which extends south for 200 km to the vicinity of Cree Lake. The shoreline vegetation type is White Spruce (*Picea glauca*) — White Birch (*Betula papyrifera*) whereas further inland the formation is covered with extensive stands of Jack Pine (*Pinus banksiana*). The beach west of the mouth of the Archibald River consisted of numerous pebble-free ponded areas. A zone of rushes (*Juncus balticus*) and other vegetation separated the beach from the occasional patches of pebbles adjacent to a willow-covered foredune. About 20 m inland from the foredune, the partially vegetated slope of the dune rose approximately 30 m above the level of the shoreline. Near the top of the dune was an extensive gravel pavement consisting of pebbles lying on the surface of the sand. The pavement is the result of deflation; the removal of sand grains by wind and the subsequent concentration of the pebbles (Schreiner et al. 1981). The gravel pavement of the Wolverine Dune is situated within 100 m of the shoreline of the lake. These pavements are unique features of the Athabasca Sand Dunes.

Two adult Piping Plovers were observed 13 July 1982 on the gravel pavement near the edge of the Wolverine Dune ridge, 500 m west of Archibald River on Lake Athabasca (59° 08′N, 108° 25′W). Two adults were seen later that evening on the beach nearer the mouth of the river, about 100 m from the previous location; one was emitting extended trills (possible scolding notes) in reaction to the presence of the other. Three flightless chicks, estimated to be no more than two days old, accompanied those adults. Three adults were observed late on 14 July, one near the mouth of the river, and one pair with chicks near our camp approximately 500 m west of the river. That pair was probably the one which was observed earlier on the dune ridge. On the evening of 15 July, one adult, now with four chicks, was near the camp, and they were also observed several times on 16 July, when the chicks were ranging further afield. Another adult, probably the other member of the pair, was seen nearer the mouth of the river on 16 July. A two-note "peep-lo", the regular call-note of the Piping Plover, was heard from the adult with the chicks during the period of observation.

Thus, one pair of Piping Plovers nested, probably within the gravel pavement on top of the dune ridge, brought their chicks down to the beach where they were observed by the author, and then separated, one bird remaining with the young. The third adult may have been an unpaired bird, possibly a product of a previous year's nesting, or part of a second pair. That there may have been a nesting in a previous year is supported by my observation of one adult Piping Plover at the same spot on the beach at Wolverine Point 16 June 1981, during a two hour visit. That bird was accompanied by two adult Semipalmated Plovers (*Charadrius semipalmatus*). Semipalmated Plovers accompanied by full-grown chicks were also observed in 1982 at Wolverine Point and along a 7 km stretch of Thomson Bay, about 45 km to the west. Nero (1963) described the occurrence of *C. semipalmatus* in the Athabasca Sand Dunes. Piping Plovers, however, were present in 1981-82 only at Wolverine Point, although the habitat elsewhere appeared similar.

This establishes the breeding of the Piping Plover in northern Saskatchewan, 685 km northwest of the most northerly reported breeding location in the province, on the Saskatchewan River west of Nipawin

(53° 17′N, 104° 18′W) (R. Godwin, Saskatchewan Research Council personal communication; Renaud et al. 1979), and 662 km due north of a nest on an island in Jackfish Lake (53° 02′N, 108° 23′W) (Renaud 1974). The species also breeds north to Beaverhill Lake in Alberta (Salt and Salt 1976) and to Dawson Bay, Lake Winnipegosis, in Manitoba (Godfrey 1966), both locations also at approximately 53° North Latitude.

Renaud (1974) stated that Piping Plovers in Saskatchewan prefer pebble beaches as nesting sites. The proximity of gravel pavement (where the plovers probably nested) and shoreline may be a factor in Piping Plovers occurring only at Wolverine Point on Lake Athabasca. No Piping Plovers were observed in the Athabasca Sand Dunes in 1979 and 1980 during studies by the Saskatchewan Research Council (Polson 1981) nor during R. W. Nero's surveys in 1958-60 (Nero 1963). Thus there is an apparent disjunction in the breeding range of this species in Saskatchewan, probably owing to the lack of suitable sand-gravel beaches between 53° North and Lake Athabasca. That vast area of northern Saskatchewan has never been extensively surveyed for birds. Some suitable habitat may occur at large lakes south of the Precambrian Shield, however, I suspect that the Shield area between La Ronge and Cree Lake contains no nesting habitat. Between Cree Lake and Lake Athabasca, where the sandstone of the Athabasca Formation covers the Shield, there may be some extensive sand beaches, although gravel may be lacking.

The only area where gravel deposits, in this case the gravel pavement, and extensive sand beaches are known to occur together appears to be at Wolverine Point, and Piping Plovers were observed here in two consecutive years. The reason these birds found it necessary to travel this far north may be partly explained by the loss of habitat throughout their southern range (Haig 1983) as reflected in the threatened status designation given them by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Photographs are on file at the National Museum of Natural Sciences in Ottawa, and identification was confirmed by Henri Ouellet.

Acknowledgments

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News and Comment

The Society of Canadian Ornithologists

The Society of Canadian Ornithologists was organized in the fall of 1982 to serve as a vehicle of communication ornithologists in all parts of Canada, and to provide a national voice on matters of concern to ornithologists. Membership is currently over 200, and applications are welcome from anyone with a serious interest in Canadian ornithology. The membership fee of $5.00 includes subscription to the Society's newsletter, which will be published 3-4 times per year. Applications for membership may be sent to:

Dr. Ralph D. Morris, Membership Secretary
Society of Canadian Ornithologists
Department of Biological Sciences
Brock University
St. Catherines, Ontario
L2S 3A1

Colonial Waterbird Group Meeting

The 8th Annual Meeting of the Colonial Waterbird Group will be held 4-6 October (Thursday, Friday, Saturday) 1984 at the Sheraton Inn, Ithaca, New York, U.S.A. Information about arrangements may be obtained from Dr. D. A. McCrimmon, Jr., Cornell Laboratory of Ornithology, 159 Sapsucker Woods Road, Ithaca, N.Y. 14853. Those interested in presenting a paper should contact Dr. W. E. Southern, Department of Biological Sciences, Northern Illinois University, DeKalb, Illinois 60115.

Migration of Sabine's Gull

During the breeding season of 1984, Sabine's Gulls (*Xema sabini*) will be colour-ringed and dyed (yellow) at the colony at Cambridge Bay, Victoria Island, Canada. In autumn 1984 they may be recorded from either the Pacific or the Atlantic Ocean or even the interior of North America. We are trying to locate the migratory divide in northern Canada and would be grateful to receive records of sightings of marked Sabine's Gulls, specifying locality and date.

Thijs Knol and Jan Wattel
Zoologisch Museum,
Postbus 20125, 1000 HC Amsterdam, Netherlands
or Bird Banding Office
Canadian Wildlife Service
Ottawa, Ontario, Canada K1A 0H3

Hamilton Naturalists' Club

In May 1982 the Club issued a comprehensive booklet covering the biotic contents of their club-owned Nature Reserves — "Spooky Hollow" (near Normandale, Ontario) and "Short Hills Wilderness Area" (near Fonthill, Ontario).

The contents contain lists of the flora to date, birds observed, mammals and amphibians and reptiles.

These are priced at four dollars ($4) per copy, with all monies accruing to the Club's Sanctuary Fund.

Acknowledgements, since release, state that the compilation and makeup of the booklet is "attractive" and the contents "very worthwhile".

Please remit request for copy or copies to the following address:

Hamilton Naturalists' Club
P.O. Box 5182,
Hamilton, Ontario
L8S 4L3

Ninth North American Prairie Conference

The Ninth North American Prairie Conference will be held in Moorhead, Minnesota, 29 July through 1 August 1984. The theme of the Conference, hosted by Concordia College, Moorhead State University, and North Dakota State University, is: *The Prairie: Past, Present, and Future.* The Conference program includes invited speakers, contributed papers, symposia, workshops, poster sessions, and field trips devoted to various aspects of prairie ecosystems. The ecology, management, restoration, classification, interpretation, utilization, and preservation of prairies are some of the topics scheduled for consideration. Others include prairie wetlands, landscaping with prairie species, and the ecology of pre-European people on the prairie. The latter topic is being given special emphasis at the 1984 meeting. Pre-conference and post-conference field trips are also planned for those interested.

For further information on the Conference contact:

Dr. R. H. Pemble
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Call for nominations for the Ottawa Field-Naturalists' Club Awards

Nominations are requested from Club members for the following awards:

Honorary Membership
Member of the Year Award
OFNC Service Award
Conservation Award
Anne Hanes Natural History Award

Descriptions of these are given in the *Canadian Field-Naturalist* 96(3): 367 [1982].

With the exception of Honorary Members, all nominees must be members in good standing. Nominations and a supporting rationale should be submitted no later than 15 December 1984, to W.K. Gummer, Chairman, Awards Committee, 2230 Lawn Avenue, Ottawa K2B 7B2 (telephone 596-1148).

Call for nominations for the Council of the Ottawa Field-Naturalists' Club for the Year 1985

A nominating committee has been chosen by the Council to nominate persons for election to offices and membership of the Council for the year 1985, as required by the Constitution.

We would like to remind Club members that they also may nominate candidates as officers and other members of Council. Such nominations require the signatures of the nominator and seconder, and a statement of willingness to serve in the specified position by the nominee. Nominations should be sent to the Nominating Committee, The Ottawa Field-Naturalists' Club, Post Office Box 3264, Postal Station C, Ottawa, Ontario K1Y 4J5, to arrive no later than 15 December 1984.

The Committee will also consider any suggestions for nominees which members wish to submit to it by 15 December 1984. It would be helpful if some relevant background on the proposed nominees were provided along with the suggested names.

DANIEL F. BRUNTON
Chairman, Nominating Committee

Errata

Timoney, Kevin P. 1983. Island biography of seed plants in Lake Nipigon. Canadian Field-Naturalist 97(1): 16–25.

On page 19, paragraph 4, line 3,

"$\left(\frac{A_i}{D_i^2}\right)$" should be changed to "$\left(\frac{A_i}{D_i}\right)$"

On page 21, table 3; an error occurred in a transposition of column heading: in the table, "Distance" is followed by "Spp./quad. to total spp." the correct order is "Spp./quad. to total spp." followed by "Distance".

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC): History and Progress

FRANCIS R. COOK[1] AND DALTON MUIR[2]

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Cook, Francis R., and Dalton Muir. 1984. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC): history and progress. Canadian Field-Naturalist 98(1): 63–70.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was called for by the 40th Federal-Provincial Wildlife Conference in 1976, organized in May 1977, and has been active to the present. Its membership consists of representatives of all 12 Canadian provincial and territorial governments; federal departments concerned with wild flora and fauna: Canadian Wildlife Service, Parks Canada, the National Museum of Natural Sciences, and Fisheries and Oceans; and three national non-governmental organizations: World Wildlife Fund Canada, Canadian Nature Federation, and the Canadian Wildlife Federation. It exists to develop a national list of Canadian species regarded, on the best scientific evidence available, as at risk in one of the following categories: extinct, extirpated, endangered, threatened or rare. Subcommittees of scientists specializing in major groups (birds, plants, etc.) arrange for, and approve of, status reports on candidate species. Funding for the preparation of status reports is provided by participating organizations, and the status reports, along with the more public-oriented summary sheets, are available at cost. The present series in *The Canadian Field-Naturalist* attempts to reach a wider audience than may have been previously aware of the work of COSEWIC.

Le Comité sur le statut des espèces fauniques menacées d'extinction au Canada (CSEMDC) a été crée en bortu d'une résolution adoptée à la 40ième Conférence Fédérale-provinciale sur la faune tenue en 1976. Ce comité a été mis sur pied en mai 1977 et est demeuré actif jusqu'à ce jour. Il est constitué de représentants des douze gouvernements provinciaux et territoriaux du Canada, des ministères fédéraux oeuvrant dans le domaine de la flore et de la faune sauvages (Service canadien de la faune, Parcs Canada, le Musée national des sciences naturelles, et Pêches et océans) et de trois organisations non-gouvernementales (le Fonds mondial pour la nature-Canada, la Fédération canadienne de la nature et la Fédération canadienne de la faune). Son mandat est l'établissement d'une liste des espèces canadiennes considérées en péril, soit parce qu'elles sont éteintes ou déracinées, soit parce qu'elles sont en danger ou menacées d'extinction ou rares. Des sous-comités d'experts scientifiques pour chacun de ces principaux groupes sont chargés de faire préparer, et approuver des rapports de situation sur les espèces concernées présentés au Comité pour l'assignation de leur statut. La préparation des rapports sur le statut de ces espèces a été financée par les organisations participantes et ces rapports et des fiches davantage conçues pour l'information du public sont maintenant en vente. Et la publication de sommaires de ces rapports dans *The Canadian Field-Naturalist* actuellement entreprise vise à faire connaître à un plus large auditoire qu'auparavant la structure et les réalisations du CSEMDC.

Key Words: endangered species, federal-provincial committee, summary sheets, status reports.

In 1976, 20-24 May, the Canadian Nature Federation and the World Wildlife Fund Canada cosponsored a symposium on Canada's threatened species and habitats at Carleton University in Ottawa, Ontario. At this gathering 43 contributors presented a wide-ranging selection of philosophical, historical, and scientific papers on the status of groups, species and habitats and the steps taken to protect the original Canadian fauna, flora, and intergrated ecosystems. The contributions were published the following year as a tribute to the late Wilfred A. Etherington, a former member of the Canadian Wildlife Service, through the support of Mrs. Etherington (Mosquin and Suchal 1977).

This was the first time a national conference in Canada had as its sole purpose a full focus on the plight of the threatened species and habitats throughout this country (Mosquin and Suchal 1977:v). Fourteen recommendations were passed at this meeting and by the time the proceedings were published, one vital recommendation had already been acted upon: "That the Federal-Provincial Wildlife Conference strike a standing committee consisting of representatives of the Federal and Provincial governments and appropriate conservation and scientific organizations for the purpose of establishing the status of endangered and threatened species and habitats in Canada." (Mosquin and Suchal 1977:ix)

Subsequently, the 40th Federal-Provincial Wildlife Conference, held at Fredericton, New Brunswick, 6-8 July 1976, had passed this resolution in its original wording as their resolution 6, and the Committee on Species of Endangred Wildlife in Canada (COSEWIC) was conceived. The present paper is

TABLE 1. Participation in COSEWIC 1977-1983.

ATTENDANCE AT MEETINGS	FEASIBILITY 24 March 1977	INAUGURAL 27 September 1977	2 May 1978	23 November 1978	25 April 1979	24 April 1980	7 April 1981	6 April 1982	6 April 1983
B.C.	X	X	X	X		X	X	X	X
ALBERTA	X	X			X	X	X	X	X
SASK.	X	X	X		X	X	X		
MANITOBA	X		X	X	X	X	X	X	X
ONTRAIO	X	X	X	X	X	X	X	X	X
QUEBEC	X	X		X	X	X		X	X
N.B.	X			X					
N.S.	X								
P.E.I.									
NFLD.				X		X	X		
N.W.T.		X	X			X			
YUKON		X	X			X			
C.W.S.	X	X	X	X	X	X	X	X	X
PARKS CANADA	X	X	X	X	X	X	X	X	
N.M.C.		X	X	X	X	X	X	X	X
D.F.O.				X	X	X		X	X
C.W.F.	X	X	X	X	X	X	X	X	X
C.N.F.	X	X	X	X	X	X	X	X	X
W.W.F. CANADA				X	X	X	X	X	X
SPECIES ASSIGNED STATUS	0	0	19	0	13	9	5	6	12

concerned with the resulting membership and structure of COSEWIC, the way in which it functions, and the actions it has taken.

The Need

Concern for the plight of species dangerously reduced in numbers or available habitat goes back at least to the last century and was well-developed by the beginning of the present one. In North America, the horror stories of such classic cases as the total extinction of the Passenger Pigeon and the dramatic decline of the Bison are well documented. They are clearly the result of unchecked slaughter of once-abundant animals coupled with growing pressure on their habitat for livestock, crop, service or residential land. Their extinction was not due to accident or ignorance alone, but was pushed by economic pursuits which, once in motion, got out of hand, a lesson that must not be forgotten by present or future generations. However, some species disappeared almost imperceptively and without publicity. The Labrador Duck became extinct even before it was adequately known scientifically. Other species like the Eskimo Curlew, diminished quickly to the point where it is still debated whether some few remnants exist in seldom-visited areas.

A real focus for conservation came with the heroic efforts to save the Whooping Crane. It has since become fashionable in some quarters to decry the amounts of money spent to stop the final decline of this spectacular species, and its very slow recovery still prompts debate on cost-effectiveness. However, this modest success brought the reassurance that the conservation movement so badly needs to survive. People, in time, accept disasters that they are powerless to stop, but a glimmer of success gives credibility and increased support for the whole conservation movement.

Conservation is a reaction not just to the plight of single species. The disaster of the Passenger Pigeon was only part of a general decimation of numbers for a whole covey of bird species, vulnerable in the long term because migratory journeys exposed them in many different jurisdictions to varied levels of exploitation. In 1916 the Migratory Bird Convention was signed between the United States and Canada, and the long road to co-operative regulation of hunting and protection of certain species was given a legal underpinning. For some mammals the successes were no

less effective. Gradually, trapping regulations spread across the continent to regulate the exploitation of fur-bearers. Federal officials, provinces, and states established wildlife departments which were not only concerned with regulation, but with scientific study needed as the basis for intelligent management.

After the Second World War, under the encouragement of the United Nations, the International Union for the Conservation of Nature began to evaluate the plight of all species on earth, and published the first of its editions of the Red Data Book, listing species thought to be in most critical danger of disappearing. In the United States, an independent evaluation begun under federal government support resulted in an American version of the Red Data Book. Various states also developed their own lists of vulnerable species.

In Canada, this world-wide concern for wildlife was taken up in many quarters. Provincial wildlife departments expanded their interest beyond the birds, fish and fur-bearers that had a tradition of exploitation, regulation, and expenditure of public funds. Many provinces examined the need for endangered species lists and focused more attention on the concept of preserving whole habitats. The latter approach had its roots nationally in the preservation of a commercially attractive mineral hot springs at Banff, Alberta, before the turn of the century and had rapidly spread to conserving such fabled migratory bird stopping points as Point Pelee in Ontario. With the gradual unfolding of motorized transportation throughout the continent, demand for recreation space increased. The justification for saving representative areas of natural ecosystems (often focused on scenic areas) was partly rationalized as a need for public camping and recreation places. Soon the viewpoint expanded to encompass preservation of declining species and their habitats for their own sake, not just for economic or other material values.

In the 1960's a literature specifically centred on endangered species begun to emerge in Canada. In 1970, *The Canadian Field-Naturalist* published papers by experts on rare and endangered vertebrates (McAllister, on fishes; Cook, on amphibians and reptiles; Novakowski on mammals; and Godfrey, on birds). The Canadian Wildlife Federation soon followed (1970) with popular articles by the same authors; Darryl Stewart (1975) authored a book, *Canadian Endangered Species,* and the Canadian Nature Federation and World Wildlife Fund Canada brought out their symposium volume *Canada's Threatened Species and Habitats* (Mosquin and Suchal 1977).

Individual provinces sponsored research, encouraged publication, and enacted legislation on endangered species. Conservationists pressed for additional measures to protect both species and habitats. This was a time of massive environmental studies, federally and provincially sponsored, in response to a demand that, before new exploitation occured, target areas should be examined for potential loss of unique or rare forms or habitats. Many of the data were gathered by biological consulting firms, a new "industry" that had exponential growth during the period.

One unforseen problem soon became apparent. Though lists or rare species existed, many inevitably expressed evaluations of individuals, or of local situations. Provincial lists focused only on species within their jurisdictions. There was a tendency for some conservationists, in their eagerness to precipitate action, to cite whatever list best supported their views as the "official" list, not understanding that it neither represented a consensus, nor was sanctioned nationally. There was a counter-tendency to ignore some lists, because of the limited data they contained.

In this climate, it was easy to recognize the need for development of a truly national list, drawn up with the active participation of all concerned. These would include the provinces, which had the legal responsibility for most resources in their jurisdiction; the federal government, which had agencies concerned with the national overview and all international ramifications; and the nationally-based private organizations which also had country-wide conservation concerns. Such a list, if based on the best available data and clearly supported by a consensus of scientific and management judgement from throughout Canada, could then be used with confidence by all jurisdictional authorities and fund-raising organizations. It could help focus their individual priorities on those most critical, the species for which immediate action is most urgent.

The Organization

Acting on the Federal-Provincial Wildlife Conference directive, the Canadian Wildlife Service coordinated the birth of the needed organization. On 24 March 1977, representatives from eight of the twelve provincial and territorial wildlife branches and Parks Canada responded to an invitation for a feasibility meeting. Also responding were two non-governmental organizations, the Canadian Nature Federation and the Canadian Wildlife Federation. An inaugral meeting was held 27 September 1977, and chose the name, Committee on the Status of Endangered Wildlife in Canada, COSEWIC. The National Museum of Natural Sciences joined at that time. Subsequent meetings were held 2 May 1978 and 23 November 1978 when representation of national non-governmental groups was completed with the presence of the World Wildlife Fund Canada, a group that was to play a vital part

in financial support for many status reports. The Department of Fisheries and Oceans also attended the latter session completing federal participation. From 1979 through 1983, meetings have been held annually each April. By custom, meetings have been held in Ottawa. Because of its central location, this site assures that any one provincial or territorial representation does not have to bear the expense of a trip across the entire length of the country. An exception to the practice of Ottawa meetings occurred in 1981 when, through the generosity of the Bata Centre, the annual meeting was held in Toronto.

Participation in COSEWIC has proven that its existence fulfills a national need, and Canada now speaks about its endangered wildlife with the agreement of all its provincial, federal and private sector conservation agencies.

The Relationship with CITES

Throughout, COSEWIC has had close liaison with another federal-provincial committee, CITES, the Convention on International Trade in Endangered Species. The latter has 86 signatory countries and is concerned, on a global basis, with regulating the export and import of specimens or parts of specimens (products) of species endangered through international trade. Many representatives of COSEWIC also participate in the Canadian meetings of CITES. The Canadian contribution to CITES is administered by the Canadian Wildlife Service, where there is a management authority (Mr. John Heppes, administrator) and a scientific authority (Dr. N.S. (Nick) Novakowski until his retirement, and Dr. A. (Art) Martell in 1983). Staff of the Department of Fisheries and Oceans and the National Museum of Natural Sciences, National Museum's of Canada, have served in an advisory role along with representatives of provincial wildlife branches and some other provincial institutions (notably the Royal Ontario Museum). Canada became a signatory to this Convention in 1975, predating COSEWIC formation. World meetings of CITES are held every two years in different host countries but there is a permanent international office in Switzerland. CITES lists pertain only to species that are actually endangered through world trade and serve as the basis for regulation and monitoring trade between countries of origin and commercial destinations. COSEWIC, in contrast, is concerned only with species at risk in Canada and has no regulatory powers or function.

COSEWIC Staff

When COSEWIC was inaugurated, Dr. N.S. Novakowski was designated permanent secretary in addition to a full slate of other professional duties. The Canadian Wildlife Service now provides half a person-year for this need (the only paid position on the committee) and the permanent secretary since the first inaugural year of COSEWIC has been Dalton Muir. All committee business: enquiries, minutes, duplication of status reports for distribution, arrangements for annual meetings, etc., are the responsibility of the secretary.

The chairman of COSEWIC is an elected position, held for two years at a time, with possible re-election. The first chairman was Mr. J.A. (Tony) Keith of the Canadian Wildlife Service, followed by Mr. Joe Bryant of the same organization. Recently, on Mr. Bryant's retirement, Mr. Keith has resumed the position in acting capacity. All other members of the committee are chosen by the organizations they represent, one voting member from each, nominally the director of the organization but in practice whoever from his staff he choses to represent him at any given time.

The subcommittee chairmen are usually representatives of member organizations, and their primary qualification is that they are experts in their field. In 1980, the general meeting authorized an executive committee composed of the chairman, secretary and the subcommittee chairmen to organize COSEWIC work.

Subcommittees

At an early stage, once the basic organization and proceedures were in place, it was decided that the selection of species for consideration, the initiation and preparation of stauts reports, and the editing and checking of these for accuracy required a series of scientific subcommittees, one for each major biological group, chaired by a scientist in that discipline.

The following scientific subcommittees and the past and present chairman of each have fulfilled this role: Mammals (terrestrial and freshwater): Nick Novakowski (CWS), Art Martell (CWS); Fish and Marine Mammals: Geoff Robins (FAO), Chuck Gruchy (NMNS), John Loch (FAO), R. Campbell (FAO); Birds: Henri Ouellet (NMNS), R.D. James (Royal Ontario Museum); Amphibians and Reptiles: Irene Bowman (Ontario Ministry of Natural Resources), Francis R. Cook (NMNS); Plants: George Argus (NMNS), Eric Haber (NMNS).

The question of additional scientific subcommittees has been frequently discussed, particuilarly the concern for an eventual subcommittee on invertebrates. For various reasons however, in particular the lack of a clear mandate to deal with invertebrates, these have not had a formal subcommittee to date. Status reports on invertebrates judged to be at risk are considered by the committee as a whole if such reports are submitted.

Each scientific subcommittee chairman selects a volunteer committee of experts in his field from throughout Canada to review status reports and to aid in selecting candidate species and authors for reports. In addition to the scientific subcommittees there is also a subcommittee for publicity, which has been chaired successively by Ken Brynaert (CWF), Monte Hummel (WWF) and Stephen Price (WWF).

Definitions

One of the first problems that the committee had to deal with was formulating a set of definitions of the categories that it would use. The following definitions are in use at the time of writing:

SPECIES: "Species" means any species, subspecies, or geographically separate population. [In other words, the committee is concerned not just with species in the taxonomic sense, but also distinctive races and isolated populations within species.]

RARE SPECIES: Any indigenous species of fauna or flora that, because of its biological characteristics, or because it occurs at the fringe of its range, or for some other reason, exists in low numbers or in very restricted areas in Canada but is not a threatened species.

THREATENED SPECIES: Any indigenous species of fauna or flora that is likely to become endangered in Canada if the factors affecting its vulnerability do not become reversed.

ENDANGERED SPECIES: Any indigenous species of fauna or flora whose existence in Canada is threatened with immediate extinction through all or a significant portion of its range, owing to the action of man.

EXTIRPATED SPECIES: Any indigenous species of fauna or flora no longer existing in the wild in Canada but existing elsewhere.

EXTINCT SPECIES: Any species of fauna or flora formerly indigenous to Canada but no longer existing anywhere.

In considering the assignment of a species to one of the above categories, the committee has sometimes found that the species does not meet the criteria set out in any of the definitions. This usually happens for one of two reasons. The data submitted may clearly show that the species is widespread and/or abundant enough that it is not of immediate concern. In other cases, an assignment cannot be made because the data available are simply too meager for a decision. In both cases, the committee has designated such proposed species as "not in any category" (N.I.A.C.). However, it is more common for species that do not fit one of the existing definitions to be held over for more investigation and reconsideration at a later date. As is evident from the definitions, COSEWIC is concerned primarily with species' status in Canada, irregardless of abundance elsewhere.

Status Reports

In order to designate a status for a species, the committee insists that a status report be prepared which brings together all existing information concerning that species.

Although subcommittee chairmen may use headings most appropriate for their discipline, the following are widely used:

A. Abstract
B. Distribution
C. Protection
D. Population size and trends
E. Habitat
F. General Biology
   1) Reproductive capability
   2) Species movement
   3) Behaviour, adaptability
G. Limiting factors
H. Special significance of the species
I. Evaluation
J. References
K. Acknowledgments

Management recommendations are not now included in the body of the report, but authors are encouraged to point out such options, because in the process of evaluating all available information, they are often able to propose some potentially effective measures. These recommendations may be presented as a separate appendix, (not part of the published manuscript), and forwarded to the appropriate jurisdictions for consideration and possible action. The reason for omitting them from the formal report is to emphasize that COSEWIC is purely a committee for evaluation and assignment of status. It has no legislative nor management role, and these must clearly be left to the authorities which have this responsibility. Such recommendations are therefore solely an author's opinion and are not that of a subcommittee or of COSEWIC.

Funding for Status Reports

COSEWIC has no budget of its own, beyond what CWS provides for the salary of the secretary and office overhead. The cost of the preparation of status reports was originally borne by any agency submitting them for consideration. It was agreed that status would be determined from the best available information, published or not, because new, up-to-date, or complete information could cause years of delay, and costs beyond any foreseeable capability of COSEWIC. However, through contracts to interested and active workers in certain fields, a surprising amount of original work has been done and incorporated into the reports. This has been possible

because many contractors have used contract funds to support field investigations, and essentially prepared the report manuscripts free of charge, or at least at little profit for themselves. Also, it has been possible to take advantage of certain studies funded by the individual provinces or by the World Wildlife Fund Canada where the researcher would incorporate his results into a status report at no additional cost. One large project on endangered species of fish was funded as an unsolicited proposal to the Department of Supply and Services for the first year with additional costs being picked up in subsequent years by the National Museum of Natural Sciences and the Department of Fisheries and Oceans. Although several individual provinces have contributed status reports, perhaps the largest contributor has been Ontario because its unique geographic position gives it more southern peripheral species than most, and therefore a disproportionate share of species at risk. This contribution has been possible because Ontario has a specially active non-game program which produces status reports for internal use. These are sometimes readily modified for COSEWIC consideration.

The cost of status reports varies depending on the amount of available literature and the range of the species. Some early reports were done for as little as $300 each, but typical costs now range between $1000 and $2000 each.

The World Wildlife Fund Canada has been a major supporter of status reports. Monte Hummel, Executive Director, first succeeded in obtaining private donor funding from the Richard Ivey Foundation, amounting to $49 000, spread over three years. After the Ivey Foundation grant was used up, The World Wildlife Fund Canada itself offered to match each dollar raised by jurisdictions for the production of status reports up to yearly limits of $20 000 in 1982, $15 000 in 1983, and $10 000 in 1984. Many federal and provincial agencies have taken up this challenge.

Originally, it was hoped that concerned conservation movements and individuals outside of COSEWIC would contribute status reports, without the committee needing to spend time and effort raising funds. Unfortunately, this has not proved to be the case. However, the proposal of species and the preparation of a status reports in the COSEWIC format is open to concerned groups or individuals at any time. Any interested group or individual should first contact the secretary, who will then put them in touch with the proper subcommittee chairman.

Designation of Status

The first status designations were made at the 2 May 1978 meeting, less than two years after the committee was authorized, and barely a year after the inaugural meeting. As of December 1983, 66 species and races had been assigned a status designation (Table 2). Status reports on many more species are currently in preparation.

Reports received by a subcommittee are reviewed by the subcommittee members, by other reviewers, and by the jurisdiction in which the species occur.

TABLE 2. List of species with designated COSEWIC status as of December 1983.

*N.I.A.C. = Not In Any Category

Species	MAMMALS	Status
Eastern Mole	*Scalopus aquaticus*	RARE
Vancouver Island Marmot	*Marmota vancouverensis*	ENDANGERED
Back-tailed Prairie Dog	*Cynomys ludovicianus*	RARE
Fox Squirrel	*Sciurus niger*	N.I.A.C.*
Plains Pocket Gopher	*Geomys bursarius*	RARE
Right Whale	*Eubalaena glacialis*	ENDANGERED
Bowhead Whale	*Balaena mysticetus*	ENDANGERED
Swift Fox	*Vulpus velox hebes*	EXTIRPATED
Grey Fox	*Urocyon cinereoargenteus*	RARE
Grizzly Bear	*Urus arctos*	N.I.A.C.
Newfoundland Marten	*Martes americana atrata*	N.I.A.C.
Black-footed Ferret	*Mustela nigripes*	EXTIRPATED
Badger	*Taxidea taxus*	N.I.A.C.
Sea Otter	*Enhydra lutris*	ENDANGERED
Eastern Cougar	*Felis concolor cougar*	ENDANGERED
Peary Caribou	*Rangifer tarandus pearyi*	THREATENED
Wood Bison	*Bison bison athabascae*	ENDANGERED
Wolverine	*Gulo gulo*	RARE
Long-tailed Weasel (Prairies)	*Mustela frenata longicauda*	THREATENED
Humpback Whale	*Megaptera novaeangliae*	THREATENED

(continued)

TABLE 2. (concluded)

*N.I.A.C. = Not In Any Category

Species		Status
MAMMALS		
St. Lawrence Beluga	*Delphinapterus leucas*	ENDANGERED
Blue Whale	*Balaenoptera musculus*	RARE
BIRDS		
American White Pelican	*Pelecanus erythrorhynchos*	THREATENED
Double-crested Cormorant	*Phalacrocorax auritus*	N.I.A.C.*
Trumpeter Swan	*Cygnus buccinator*	RARE
Ferruginous Hawk	*Buteo regalis*	THREATENED
Gyrfalcon	*Falco rusticolus*	N.I.A.C.
Peregrine Falcon:	*Falco peregrinus*	
	F. p. pealei	RARE
	F. p. tundrius	THREATENED
	F. p. anatum	ENDANGERED
Greater Prairie-Chicken	*Tympanuchus eupiclo pinnatus*	ENDANGERED
Whooping Crane	*Grus americana*	ENDANGERED
Greater Sandhill Crane	*Grus canadensis tabida*	N.I.A.C.
Piping Plover	*Charadrius melodus*	THREATENED
Eskimo Curlew	*Numenius borealis*	ENDANGERED
Ivory Gull	*Pagophilia eburnea*	RARE
Caspian Tern	*Sterna caspia*	RARE
Burrowing Owl	*Athene cunicularia*	THREATENED
Great Gray Owl	*Strix nebulosa*	RARE
Kirtland's Warbler	*Dendroica kirtlandii*	ENDANGERED
Savannah Sparrow ["Ipswich" race]	*Passerculus sandwichensis princeps*	RARE
Ross' Gull	*Rhodostethia rosea*	RARE
Red-necked Grebe	*Podiceps grisegena*	N.I.A.C.
Prairie Falcon	*Falco mexicanus*	N.I.A.C.
Red-shouldered Hawk	*Buteo lineatus*	RARE
Cooper's Hawk	*Accipiter cooperii*	RARE
REPTILES AND AMPHIBIANS		
Leatherback Turtle	*Dermochelys coriacea*	ENDANGERED
FISH		
Shortnose Sturgeon	*Acipenser brevirostrum*	RARE
Speckled Dace	*Rhinichthys osculus*	RARE
Giant Strickleback	*Gasterosteus* sp.	RARE
Blueback Herring	*Alosa aestivalis*	N.I.A.C.
Spotted Gar	*Lepisosteus oculatus*	RARE
Spotted Sucker	*Minytrema melanops*	RARE
Silver Shiner	*Notropis photogenis*	RARE
River Redhorse	*Moxostoma carinatum*	RARE
Charlotte Unarmoured Stickleback	*Gasterosteus* sp.	RARE
Acadian Whitefish	*Coregonus canadensis*	ENDANGERED
Shorthead Sculpin	*Cottus confusus*	THREATENED
PLANTS		
Furbish's Lousewort	*Pedicularis furbishiae*	ENDANGERED
Small White Lady Slipper	*Cypripedium canidum*	ENDANGERED
Tyrrell's Willow	*Salix planifolia tyrrellii*	THREATENED
Athabasca Thrift	*Ameria maritima interior*	THREATENED
Small Whorled Pogonia	*Isotria medeoloides*	ENDANGERED
Kentucky Coffee Tree	*Gymnocladus dioica*	THREATENED
Blue Ash	*Fraxinus quadrangulata*	THREATENED
Broad Beech Fern	*Phegopteris hexagonaptera*	RARE

They may be returned to the author for major or minor revision. After a report has been accepted by the subcommittee, it is distributed to members of the full committee for a postal ballot review. Voters are asked to state which, if any, category they wish to see the species placed. Postal ballots are not binding but give a sampling of opinion to guide members at the annual meeting. The postal vote is read at that time, and different points of view are discussed. A final vote is then taken, and a majority decision determines official status. Species of animal life which have been assigned threatened or endangered status are subsequently published federally in the *Canada Gazette*, to give official notice of the action; most plants, however, are not within federal jurisdiction.

It is important to realize that status assignments are not permanent. They are based on the best information available at the time, and may be reviewed whenever new information becomes available. If such is the case, an updated status report is prepared. It is possible to re-designate a species into a more critical category should its prospects for continued survival deteriorate, or the status of a species may be changed to a less critical category when risk diminishes. The hope of all members is that most species will eventually be downlisted, or delisted entirely, because of better prospects for their survival.

Publication

Accepted status reports are available in the original form and language with introduction and logo-cover, as "printing cost recovery items", from the Canadian Nature Federation, Ottawa. In addition to the status reports, the author or the subcommittee prepares a single page (two-sided) summary sheet for species designated as either threatened or endangered. These simplified versions are printed by the Canadian Wildlife Federation, Ottawa, and sold at cost to provincial and other agencies for free distribution to the public, especially to schools.

Although the summary sheets are fairly widely distributed, the availability of the original status reports seems relatively unknown, and this has been a matter of concern to the committee. For this reason the history of the committee and the progress of its work has been outlined in this article, and is followed by an edited version of 10 accepted status reports on fish, prefaced by an introduction by the subcommittee chairman. Publication of these status report has been possible through the generous support of Department Fisheries and Oceans. If further support is forthcoming the series will be continued in future issues of *The Canadian Field-Naturalist,* and the News and Comment section will carry notice of further species designations, updating the list in Table 2, and comment on subsequent COSEWIC meetings and other decisions taken.

Acknowledgments

We are grateful to our respective institutions for their support and encouragement. Tony Keith has been actively involved with COSEWIC since its inception, and was chairman much of the time. Louis Lemieux, Hugh Schultz, Chuck Gruchy, Henri Ouellet, Jim Soper and Ernie Brodo have supported the efforts of National Museums staff through the years by allowing time for COSEWIC duties. We owe special thanks to Nick Novakowski, who has worked for action on endangered species throughout most of his professional career at the Canadian Wildlife Service, and who has been a particular inspiration to the committee and to each of us throughout. George Argus, National Museum of Natural Sciences, has also made an unforgettable contribution, not only as the first plant subcommittee chairman but with his frank and erudite remarks at every meeting he attended. All jurisdictions and organizations have sent dedicated representatives over the years. The provincial members have been the backbone of success of COSEWIC meetings and final status decisions. Bill Munro (B.C.), Merlin Shoesmith (Manitoba), and Irene Bowman (Ontario) and many others could be singled out for their long attendance. Monte Hummel and Stephen Price of the World Wildlife Fund Canada have taken much of the administrative load of raising funds and managing them. We also thank the authors of status reports who have done the work, often for little compensation other than the knowledge that their contribution may assist the conservation of a single species. We are especially grateful to Bob Campbell for championing the publication support by Fisheries and Oceans, and for editing the following reports. We also owe him an apology for ruthless cutting of his original introduction to the fish reports. Some of his material has been incorporated here.

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Rare and Endangered Fishes of Canada: The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Fish and Marine Mammals Subcommittee

R. R. CAMPBELL

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Campbell, R. R. *Editor*. 1984. Rare and Endangered Fishes of Canada: The Subcommittee on the Status of Endangered Wildlife in Canada (COSEWIC) Fish and Marine Mammals Subcommittee. Canadian Field-Naturalist 98(1): 71–74.

The Fish and Marine Mammals Subcommittee of COSEWIC, formed in 1979, arranges the preparation of status reports on selected species believed in jeopardy in Canada and presents these for status designation at COSEWIC general meetings. The subcommittee has presented status reports on 10 species of fish and 6 of marine mammals which have since been classified by COSEWIC. An additional 50 status reports are under review or are being considered for fishes in Canada and 10 more concern marine mammals. This presentation outlines the actions of the subcommittee to date and serves to introduce the 10 status manuscripts on fish that follow.

Le Sous-comité du poisson et de mammifères-marins et ceux-ci à fait la critique de les rapports de situation sur 10 espèces de poissons et 6 de mammifères marines et ceux-ci ont eu présenter au CSEFMEC qui les a classifiés. Une additionnel 50 rapports de situation sont passer en revue ou sont prendre en consideration sur des poissons au Canada et aussi 10 sur des mammifères-marins. Cette présentation tente d'exposer à grands traits, dans ses lignes générales les functions du Sous-comité et servir comme un éditorial sur les 10 manuscrits qui suivre. [Traduit par l'auteur]

Key Words: COSEWIC, fish and marine mammals, endangered, jeopardy, Canada.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was organized in 1977, under the auspices of, and at the request of the Federal-Provincial Wildlife Conference. The justification, philosophies, ideals and operation of COSEWIC have been previously described by Cook and Muir (1984. *Canadian Field-Naturalist* 98(1): 63–70) who explain the role of COSEWIC in providing a vehicle for the production, review and circulation of information on the status of those species of plants and animals in Canada which may be in jeopardy and to establish a national consensus on that status.

The assignment of status by COSEWIC is achieved following a careful review of the basis of detailed scientific information provided in the form of status reports prepared by the member jurisdictions or by learned individuals deemed best suited to evaluate the information. These status reports are the property of COSEWIC, but copies are made available, at cost, to any individual or agency through the Canadian Nature Federation (Cook and Muir 1984).

Fish and Marine Mammals Subcommittee

The Fish and Marine Mammals Subcommittee was first formed in 1979 under the chairmanship of Geoff Robbins, Fisheries and Oceans Canada. FAO has broad responsibilities throughout the fresh and marine waters of Canada under cooperative arrangement with the provinces. Marine mammals were included with fish because, in Canada, historically and at present, both come under the mandate of the Federal Department of Fisheries and Oceans (Fisheries Act, Revised Statutes of Canada 1976-77). Even in those provinces and territories where proprietary rights allow for provincial jurisdiction over fisheries, marine mammals remain under the jurisdiction of the Department of Fisheries and Oceans, as they usually occur in offshore marine waters.

The functions of the Fish and Marine Mammals Subcommittee are handled by a chairman who selects a panel membership of learned scientists from across the country. These scientists serve as a source of suggestions for species of interest (i.e., species which may be in jeopardy) and they act as reviewers of solicited reports when received. The chairman also looks to provincial, territorial and non-government wildlife agencies as sources of species which should be given priority. Based on input from the subcommittee members and various jurisdictions and agencies, a priority list is produced and individuals are sought to produce a status report on each species (see Cook and Muir 1984 for format of a typical status report).

Upon receipt, the draft report is circulated to the subcommittee for review and comment. Final manuscripts are sent to provincial and territorial jurisdictions for comment and then to COSEWIC members for consensus and assignment of status, if necessary.

Rare and Endangered Fish and Marine Mammals

To date, 10 species of fish and 6 species of marine mammals have been assigned COSEWIC status in Canada (Table 1). On occasion, a species considered not to be in jeopardy will be designated "not be in any [COSEWIC] category" (N.I.A.C.). This has occurred with the Blueback Herring, *Alosa aestivalis* (see footnote: Table 1) and will probably be the case with the Mackenzie Bay (Beaufort Sea) stocks of the Beluga (see Table 2).

At present, status reports on an additional 26 fishes and 8 marine mammals are either in progress or under review (Table 2). This faces the subcommittee with a priority list of 14 fishes and 2 marine mammals yet to be considered (Table 3). This list will, no doubt, see changes in the future as additional species are found to be in jeopardy. It is important to note that all listed species are monitored continually and, from time-to-time, updated status reports are prepared in order to determine whether the designated status has changed since it was originally assigned (see Table 2).

One will also notice from the tables (Tables 1-3) that the five levels of concern, or "status" i.e. rare, threatened, endangered, extirpated, or extinct (see Cook and Muir 1984) may be applied to species, sub-species or geographically isolated populations. Beluga, for example, are being examined on the basis of populations, i.e., St. Lawrence River, Northern Québec, Mackenzie Bay, Cumberland Sound (Tables 1 and 2) and sticklebacks and dace on geographical isolation (Tables 1-3). In some cases, we are confronted with small isolated populations of certain species which, in the case of the Spotted Sucker or Silver Shiner (Table 1) are at the extreme northern end of their range. Although these populations may be in no jeopardy further south, in Canada, due to their limited range and number, they are usually rare. Regardless of the status of populations elsewhere, there is a need to consider any species which may be in jeopardy in Canada and to bring it to the attention of the public and the government and non-government agencies concerned with protection and conservation.

Concluding Remarks

The following 10 articles are reports on the status of 10 species of fish which have come to COSEWIC attention and have been assigned an official COSEWIC status.

If we take one example, that of the Acadian Whitefish, we can see that the concepts and philosophies of the committee are valid and produce results.This fish was thought to be extinct and a Canadian postage stamp was issued to commemorate the species. Following reports of possible sightings, a status report was commissioned and it was determined that the fish was not extinct but was indeed "in danger of extinction." As a result of COSEWIC attention, the province of Nova Scotia and the federal Department of Fisheries are undertaking actions to ensure the protection and conservation of the species. As well, T. Edge continues to monitor the species for changes in status.

Status reports, their text and format are the property of COSEWIC and the 10 presented in this volume are

TABLE 1. Fish and marine mammal species with COSEWIC-assigned status, to December 1983*

Species	Scientific Name	Status	Date assigned
FISH			
Shortnose Sturgeon	*Acipenser brevirostrum*	Rare	April 1980
Spotted Gar	*Lepisosteus oculatus*	Rare	April 1983
Acadian Whitefish	*Coregonus canadensis*	Endangered	November 1983
Silver Shiner	*Notropis photogenis*	Rare	April 1983
Speckled Dace	*Rhinichthys osculus*	Rare	April 1980+
Spotted Sucker	*Minytrema melanops*	Rare	April 1983
River Redhorse	*Moxostoma carinatum*	Rare	April 1983
Mayer Lake Stickleback	*Gasterosteus* sp.	Rare	April 1980
Charlotte Unarmoured Stickleback	*Gasterosteus* sp.	Rare	April 1983
Shorthead Sculpin	*Cottus confusus*	Threatened	November 1983
MARINE MAMMALS			
Sea Otter	*Enhydra lutris*	Endangered	May 1978
Blue Whale	*Balaenoptera musculus*	Rare	April 1983
Bowhead Whale	*Balaena mysticetus*	Endangered	April 1980
Humpback Whale	*Megaptera novaeangliae*	Threatened	April 1982
Right Whale	*Eubalaena glacialis*	Endangered	April 1980
St. Lawrence River Beluga	*Delphinapterus leucas*	Endangered	April 1983

*The Blueback Herring, *Alosa aestivalis*, was investigated and found not to be in any COSEWIC category
+Updated April 1983 — no status change

TABLE 2. Fish and marine mammal species for which status reports are in preparation, or under review — December 1983

Species	Scientific Name	Proposed Status
FISH		
Lake Lamprey	*Lampetra macrostoma*	Rare
Paddlefish	*Polydon spathula*	Extirpated
Aurora Char*	*Salvelinus fontinalis timagamiensis*	Extirpated
Bloater	*Coregonus hoyi*	Rare
Deepwater Cisco	*Coregonus johannae*	Endangered
Kiyi	*Coregonus kiyi*	Rare
Shortnose Cisco	*Coregonus reighardi*	Threatened
Blackfin Cisco	*Coregonus nigripinnis*	Threatened
Longjaw Cisco	*Coregonus alpenae*	Extinct
Squanga Whitefish*	*Coregonus* sp.	Threatened
Pygmy Smelt	*Osmerus spectrum*	Rare
Common Stoneroller	*Campostoma anomalum*	Rare
Redside Dace	*Clinostoma elongatus*	Threatened
Silver Chub	*Hybopsis storeriana*	Rare
Gravel Chub	*Hybopsis x-punctatata*	Extirpated
Pugnose Shiner	*Notropis anogenus*	Endangered
Bigmouth Shiner	*Notropis dorsalis*	Rare
Pugnose Minnow	*Notropis emiliae*	Endangered
Banff Longnose Dace*	*Rhinichthys cataractae smithi*	Endangered
Umatillus Dace	*Rhinichthys umatillus*	Rare
Blackstripe Topminnow	*Fundulus notatus*	Endangered
Campbell Sucker	*Catostomus* sp.	Endangered
River Redhorse	*Moxostoma carinatum*	Rare⁺
Copper Redhorse	*Moxostoma hubbsi*	Threatened
Brindled Madtom	*Noturus miurus*	Endangered
Blue Walleye	*Stizostedion vitreum glaucum*	Extinct
MARINE MAMMALS		
Foxe Basin Walrus	*Odobenus rosmarus*	?
Cumberland Sound Beluga	*Dephinapterus leucas*	?
McKenzie Bay Beluga	*Dephinapterus leucas*	Common
Northern Québec Beluga	*Dephinapterus leucas*	Endangered
Blue Whale	*Balaenoptera musculus*	Rare⁺
Bowhead Whale	*Balaena mysticetus*	Endangered⁺
Humpback Whale	*Megaptera novaeangliae*	Threatened⁺
Right Whale	*Eubalaena glacialis*	Endangered⁺

*Endemic to Canada
⁺Status as indicated already assigned (see Table 1). These are updated status reports.

published under the name of the original author. They appear very much as received by COSEWIC (after subcommittee review) but have undergone editing to give some degree of commonality in form and presentation. Brief introductions have been added.

Acknowledgments

I would like to acknowledge the authors for their efforts and interest in COSEWIC, and the Publications Committee of this journal for their consideration and cooperation. A special note of gratitude is due to D. E. McAllister of the National Museum of Natural Sciences, who has long actively served the committee, for his comments and assistance and for the provision of figures and maps, and also to P. McKee of Beak Consultants for provision of range maps. Publication costs were kindly provided through the Department of Fisheries and Oceans.

Thanks are also due to past chairmen, particularly the energetic Geoff Robbins (1979-1980), Chuck Gruchy of the National Museum of Natural Sciences, who served as acting subcommittee chairman in 1981 in a break in Fisheries and Oceans continuity, and to John Loch (1982) of the latter department, my immediate predecessor. Dr. W. G. Doubleday of FAO has contributed here and in CITES with advice information.

The efforts of all members of the Fish and Marine Mammals Subcommittee in reviewing the reports has been greatly appreciated by chairmen past and present.

TABLE 3. Fish and Marine Mammal Subcommittee — Priority list of fish and marine mammal species for consideration of status — December 1983

Species	Scientific Name	Possible Status in Canada
FISH		
Black Redhorse	*Moxostoma duequesnei*	Endangered
Opeongo Dwarf Whitefish*	*Coregonus* sp.	Endangered
Northern Brook Lamprey	*Ichthyomyson fossor*	Rare
Green Sturgeon	*Acipenser medirostrus*	Rare
Nooky Dace	*Rhinichythys cataractae* spp.	Rare
Western Silvery Minnow	*Hybognathus argyritis*	Rare
Y-prickleback*	*Allolumpenus hypochromis*	Rare
Atlantic Sturgeon	*Acipenser oxyrhynchus*	?
Pacific Sardine	*Sardinops sagax caerulea*	Rare
Bluntnose Minnow	*Pimiphales notatus*	Rare (in some areas)
Mimic Shiner	*Notropis volicellus*	Rare (in some areas)
Banded Killifish	*Fundulus diaphanus*	Rare (in some areas)
Bigmouth Buffalo	*Ictiobus cyprinellus*	Rare to Common
Longear Sunfish	*Lepomis megalotis*	Rare to Common
MARINE MAMMALS		
Walrus	*Odobenus rosmarus*	Rare to Common
Pacific Beak Whale	*Bernardius bairdii*	?

*Endemic to Canada

Their comments and suggestions have made the process effective. These members are listed as follows:

Dr. P. F. Brodie, Bedford Institute of Oceanography.

Dr. E. J. Crossman, Curator, Ichthyology and Herpetology Department, Royal Ontario Museum.

Mr. Rolph Davis, Director, LGL Ltd.

Mr. Gareth Goodchild, Aquatic Habitat Inventory Biologist, Ontario Ministry of Natural Resources.

Dr. D. E. McAllister, Curator, Ichthyology Section, National Museum of Natural Sciences.

Dr. J. S. Nelson, Department of Zoology, The University of Alberta.

Dr. A. E. Peden, Curator of Aquatic Zoology, British Columbia Provincial Museum.

Dr. W. B. Scott, Senior Scientist, Huntsman Marine Laboratory.

Dr. C. G. van Zyll de Jong, Curator, Mammalogy Section, National Museum of Natural Sciences.

Dr. M. A. Brigg, Pacific Biological Station.

Last, but not least, I would like to acknowledge my secretaries: A. Luelo for her preseverance and care in typing this manuscript and M. Guruprasad for her unstinting efforts with the files, correspondence and reports over the years.

Status of the Shortnose Sturgeon, *Acipenser brevirostrum*, in Canada*

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Dadswell, M. J. 1984. Status of the Shortnose Sturgeon, *Acipenser brevirostrum*, in Canada. Canadian Field-Naturalist 98(1): 75–79.

The Shortnose Sturgeon is known from only one locality in Canada: the Saint John River, New Brunswick. This population, however, is the largest known for this species and is estimated to have 18 000 ± 30% adults with a total population of perhaps 100 000. The species is widespread in eastern North America from Florida to New Brunswick and the populations in each river system are now known to be larger than formerly believed. There is no evidence to suggest that Shortnose Sturgeon populations are increasing or decreasing. Present known levels, which are higher than supposed former levels, are largely a reflection of new interest for this species prompted by its endangered status in the United States. If properly managed, certain Shortnose Sturgeon populations could support small, gourmet-item fisheries.

L'esturgeon à museau court se trouve à un seul endroit au Canada, soit la rivière Saint-Jean au Nouveau-Brunswick. La population de la Saint-Jean est cependant la population la plus importante connue de cette espèce et elle est évaluée à environ 100 000 dont 18 000 ± 30% adultes. Cette espèce est dispersée dans l'est de l'Amerique du Nord, de la Floride au Nouveau-Brunswick, et la population de chaque réseau fluvial est plus nombreuse que les estimations antérieures ne l'avaient laissé croire. Rien n'indique cependant que les populations d'esturgeons à museau court augmentent ou diminuent. Le fait que les chiffres actuels soient supérieurs aux précédents est en grande partie la conséquence d'un nouvel intérêt pour cette espèce dû à son statut d'espèce menacée d'extinction aux Etats-unis. L'application de bonnes pratiques de gestion pourrait permettre l'exploitation limité de certaines populations d'esturgeons à museau court. [Traduit par R. R. Campbell]

Key Words: New Brunswick, Saint John River, sturgeon, distribution, population size and trends, rare.

The Shortnosed Sturgeon (*Acipenser brevirostrum*) is a slow-growing species which may live for up to 30 years (Magnin 1963). They are not so large as other sturgeons such as the Lake Sturgeon (*Acipenser fulvescens*), reaching a maximum length of up to 120 cm and weight of 30 kg. (Scott and Crossman 1973). The species has been described by Scott and Crossman (1973) and the following description is adopted from that source. The body (Figure 1) is dark brown to black dorsally and yellowish below. The vertical surface and barbels are white. The body is not covered with scales, but with patches of small denticels and rows of large bony scutes. These fish are found along the eastern seaboard of North America and have been of incidental commercial importance since the 1800's, as the flesh is of good quality and the eggs are suitable for caviar.

Distribution

The Shortnose Sturgeon occurs in rivers, estuaries, and in the sea, along the east coast of North America from the Indian River, Florida, north to the Saint John River, New Brunswick (Figure 2). This species lives mainly in estuarine or nearshore marine habitat about the mouths of large rivers. Populations migrate annually into freshwater for spawning and may remain there for extended periods (Dadswell 1979). One partially landlocked population is known in the Holyoke Pool of the Connecticut River, Massachusetts (Taubert 1980). It is not known if movement of Shortnose Sturgeon occurs along the coast between rivers and at present each population is thought to be distinct. There is, however, considerable documentation of their occurence at sea (Holland and Yelverton 1973; Fried and McCleave 1973; Wilk and Silverman 1976; Dadswell 1979) and some exchange between populations may occur.

Protection

The Fisheries Act of Canada of 1868 and the Amendment to the Act of 1976 requires protection and management of all commercial fish species and their habitat. In the Saint John River the "sturgeon" season is open all year except the month of June, but sturgeon are actively sought only during July-August. All "sturgeon" over 4 feet (122 cm) total length are legal. Since the Fisheries Act does not distinguish between Shortnose and Atlantic Sturgeon (*Acipenser oxyrhynchus*), the two species inhabiting the Saint John River, some Shortnose Sturgeon are landed annually (D. Gorham, personal communication). The level of exploitation by the directed sturgeon fishery is sustainable by the population (Dadswell 1975).

At present the Shortnose Sturgeon is listed as

*Rare status approved and assigned by COSEWIC 6 April 1980.

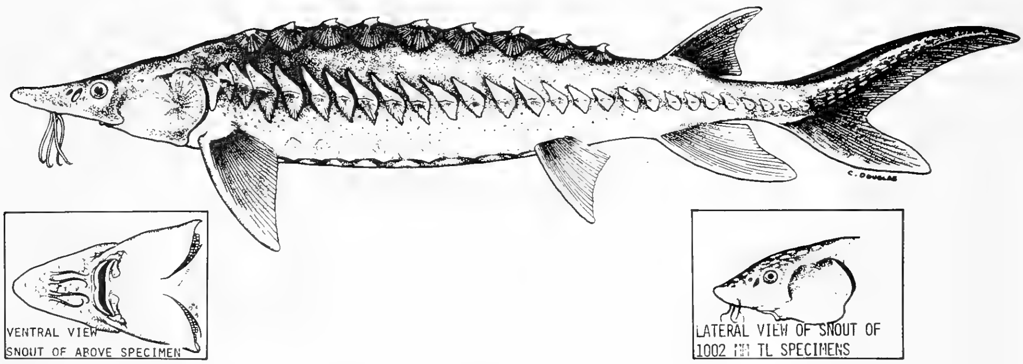

FIGURE 1. Shortnose Sturgeon, *Acipenser brevirostrum*. Courtesy of D. E. McAllister, National Museum of Natural Sciences.

endangered in the United States and is totally protected by the Endangered Species Act of 1973. As a result, no legal exploitation of the species is allowed. International trade in flesh or eggs is regulated under listing of the species on Appendix I of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES).

Population Size and Trend

The adult Shortnose Sturgeon population in the Saint John River, New Brunswick, was estimated as 18 000 ± 30 per cent (Dadswell 1979). The total population was estimated at approximately 100 000 by extrapolation of the mortality relationship (Dadswell 1979). During the course of a four-year study, over 4000 adults were actually captured.

Population sizes in American rivers to the south are lately becoming known and some of them may be as large as the Saint John population. Since the size of Shortnose Sturgeon populations was previously unknown, trends in abundance cannot be accurately determined. For example, the presence of Shortnose Sturgeon in the Saint John River, N.B., the Kennebec River, Maine, and the Altamaha River, Georgia, was unknown until the last two decades, but these apparently are three of the larger populations. Also, Ryder (1890) described himself as fortunate when he obtained five Shortnose Sturgeon from the Delaware River and said the species had not been seen since LeSueur's day, but at the same time the Geological Survey of New Jersey (Anonymous 1890) reported a 5:1 ratio of Shortnose to Atlantic Sturgeon and Meehan (1910) obtained over 100 Shortnose Sturgeon from the Delaware in April 1908 with relative ease. In the last two decades, Shortnose Sturgeon have been captured regularly in the Delaware River. Similarly, Greely (1937) observed over 100 Shortnose Sturgeon as incidental captures in the Hudson River shad fishery during 1936, but stated the species was rare. Dovel (1978) observed about 100 Shortnose Sturgeon per year as incidental catch in the same fishery during 1976 and 1977, but when directed effort for Shortnose Sturgeon with proper equipment took place in the Hudson during the spring of 1979, 1594 adults were captured in two months (Pekovitch 1979). These data, although fragmentary, suggest good populations of Shortnose Sturgeon have been present in all these rivers over the last century, but have remained largely undetected or unreported.

Habitat

The Shortnose Sturgeon occurs in rivers, estuaries and the sea but reaches its greatest abundance in mesohaline regions of the upper estuaries of large rivers. Habitat preference and migratory behaviour are influenced by latitude and the physical nature of each river system. In northern locations, the majority of the population remain within the influence of the estuary and predominantly select salinities below 20 o/oo (Dadswell 1979). Southern Shortnose Sturgeon appear to enter rivers only during the spring to spawn (Heidt and Gilbert 1978) and return to the sea for the remainder of the year (Holland and Yelverton 1973). In the Saint John River, N.B., Shortnose Sturgeon migrate to more saline portions of the lower estuary and into deep regions of the estuarine lakes to overwinter (Dadswell 1979). In spring, the reproductives of the population for that year migrate upstream to spawn in riverine regions of strong flow (60-120 cm/s) over sand, gravel or boulder substrate (Pekovitch 1979; Taubert 1980). In some rivers, spawning migration may be as far as 200-km upstream. In the Saint John River, one spawning site is the region of the river between Mactaquac Dam and

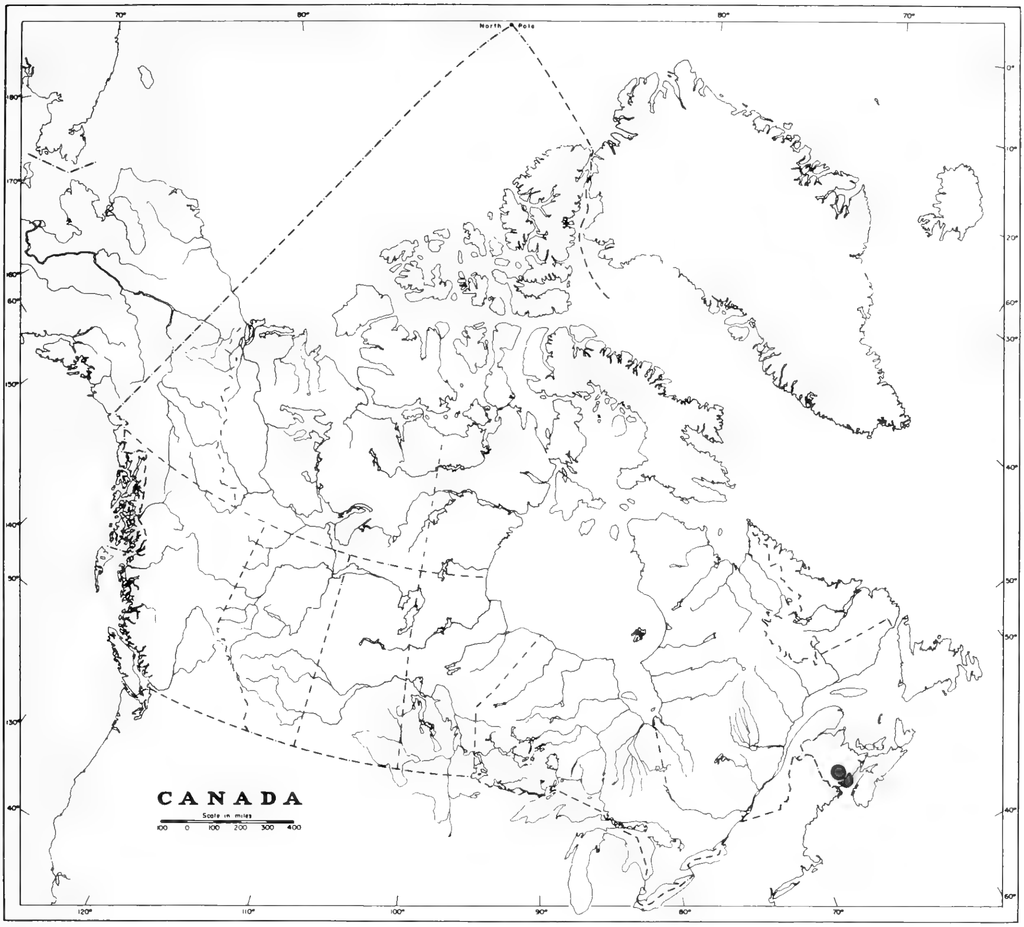

FIGURE 2. Canadian distribution of the Shortnose Sturgeon (*Acipenser brevirostrum*). Courtesy of D. E. McAllister, National Museum of Natural Science.

Fredericton (Dadswell, personal observation). Juveniles spend their first years in deep riverine portions of the upper estuary, predominantly in fresh water (Dadswell 1979).

General Biology

Shortnose Sturgeon spawn during early spring in the freshwater portions of estuaries or in rivers. Spawning occurs during flood conditions at water temperatures of 10-12°C (Dadswell 1979; Taubert 1980). Eggs are probably broadcast and fertilization is external. Upon fertilization, the eggs become adhesive and attach to bottom materials (Meehan 1910). Hatching takes place in 13 days at 10°C (Meehan 1910). At hatching, larvae are 9-12 mm in length, grey-black and demersal (Taubert and Dadswell 1980). Growth is rapid during the first year of life (Pekovitch 1979).

Further growth varies greatly depending on latitude, the fastest growth occurring among southern populations, but fish from northern populations attain a larger size. In the Saint John River, N.B., the species attains 50 cm fork length after 10 years, 90 cm fork length after 25 years, and 100 cm fork length after 35 years. Maximum known size of Shortnose Sturgeon in the Saint John River is 143 cm total length

and 23 kg. Maximum age is 67 years for females, but males seldom exceed 30 years of age (Dadswell 1979). Sex ratio among young adults is 1:1, but changes to a predominance of females among fish greater than 90 cm fork length. Total instantaneous mortality is in the range of 0.12-0.15 for the Saint John population.

Shortnose Sturgeon are benthos feeders. The juvenile diet consists of insect larvae and crustaceans. Adult Shortnose Sturgeon eat predominatly molluscs.

Female Shortnose Sturgeon mature between 50 and 60 cm fork length and spawn for the first time between 55 and 75 cm fork length. In the Saint John, 50 percent maturity and age of first spawning corresponds with 15 and 18 years of age. Males mature between 45 and 50 cm fork length and spawn within a year of reaching maturity at a mean age of 10. The minimum duration between spawning of individual females is three years, but males spawn yearly or every other year. Fecundity of females is between 40 000 and 200 000 eggs and is directly correlated to total weight.

Limiting Factors

The limiting factor for Shortnose Sturgeon in Canada is the availability of large rivers with warm water estuaries. The Shortnose Sturgeon in this region is at the northern extent of its range and probably at the extreme thermal limit for a reproducing population. The species may occur in other estuaries around the Bay of Fundy, or in the warm water estuarine complex around the mouth of the Miramichi River, but has remained undetected either because of confusion with Atlantic Sturgeon, or because of limited sampling. Estuarine pollution may be detrimental, but even in a river as badly polluted as the Hudson a considerable population has survived (Dadswell 1979).

The Shortnose Sturgeon is taken as incidental catch in the shad, salmon and bass gillnet fishery and by the Alewife (*Alosa pseudoharangus*) trapnet fishery. On the basis of tag returns, Dadswell (1979) estimated the fishing mortality from this exploitation as 0.01 per year but this may be an underestimate. Much of the incidental catch from the gillnet fishery is returned to the river unharmed but some are sold locally. Unfortunately Shortnose Sturgeon from the Alewife trapnet fishery are often shipped with the Alewives to be made into fish meal.

Special Significance of the Species

The Shortnose Sturgeon is classified legally as "endangered" in the United States, but since this status comes up for review every three years and recent studies have shown the species may be as abundant as it ever was, the status could change. The species is a significant component of the Saint John River benthic fish fauna. The flesh is good quality and the eggs suitable for caviar.

Evaluation

It appears the population of Shortnose Sturgeon in the Saint John River is at, or near, the carrying capacity for the habitat available (Dadswell 1975). Incidental catch in other commercial fisheries and directed catch in the sturgeon fishery is not exceeding the sustainable yield for the population.

Since the Shortnose Sturgeon is abundant in the Saint John River, and there is a good possibility the species may be found in other Maritime rivers; the species cannot be considered endangered in Canada. Because American populations are proving to be larger and more numerous than supposed, there is a distinct possibility the species could be removed from the U.S. endangered species list in the next five years. However, the Saint John River has to date the only known population of this species in Canada, and every effort to protect this river and its estuary from degradation or pollution should be undertaken. The species could be left in the "rare" category until evidence of either a decline of the Saint John River population or the occurrence of other self-sustaining maritime populations is available.

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Status of the Spotted Gar, *Lepisosteus oculatus*, in Canada*

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Parker, B., and P. McKee. 1984. Status of the Spotted Gar, *Lepisosteus oculatus*, in Canada. Canadian Field-Naturalist 98(1): 80–86.

The Spotted Gar, *Lepisosteus oculatus*, is rare in Canada. It occurs in the fresh and brackish waters of central and south-central North America. Its range in Canada is limited to southern Ontario where populations, if extant, are extremely small. The Spotted Gar is found in the Great Lakes drainage, together with the Longnose Gar, *Lepisosteus osseus*, and the Shortnose Gar, *Lepisosteus platostomus*, although it is sympatric only with the Longnose Gar in Canada. Only 13 specimens of Spotted Gar have been collected from Canadian waters since it was first reported in 1913, and information on its preferred habitat and general biology has relied, essentially, on studies carried out in U.S. waters. Due to its infrequent occurrence in Canadian waters, its status in Canada is rare. Elsewhere, the Spotted Gar is considered endangered only in Ohio. There are no indications that this species is threatened in other parts of its range. There are no impending developments that will pose an immediate threat to the welfare of this species in Canada.

Le lépisosté tacheté, *Lepisosteus oculatus*, fréquente les eaux douces et saumâtres du centre et du centre sud de l'Amérique du Nord. Il ne se recontre au Canada qu'au sud de l'Ontario. Le Lépisosté tacheté se trouve dans le bassin des Grands lacs, en compagnie du lépisosté osseux, *Lepisosteus osseus* et du lépisosté à nez court, *Lepisosteus platostomus*, bien qu'au Canada, il soit associé seulement au lépisosté osseux. Depuis qu'on l'a signalé pour la première fois en 1913, seulement 13 spécimens de *Lepisosteus oculatus* ont été récoltés dans les eaux canadiennes, et les informations sur l'habitat favori et la biologie générale de l'espèce reposent essentiellement sur des études effectuées dans les eaux américaines. En raison de sa présence peu fréquente dans les eaux canadiennes l'espèce est rare au Canada. Ailleurs, le lépisosté tacheté est considéré comme espèce menace d'extinction dans l'Etat d'Ohio seulement. Il n'y a rien qui laisse croire que cette espèce soit menacée dans d'autres parties de son aire de dispersion. Aucun projet d'aménagement ne menace dans l'immédiat cette espèce au Canada. [Traduit par R. R. Campbell]

Key Words: Ontario, Lake Erie, Lake St. Clair, gars, distribution, population size and trends, rare.

Of the two Shortnosed Gar in North America, only the Spotted Gar (*Lepisosteus oculatus*) occurs in Canadian waters; the Shortnose gar (*Lepisosteus platostomus*) has not been recorded (Scott and Crossman 1973). The Spotted Gar is found only rarely. This species (Figure 1) has been described by Scott and Crossman (1973) as velvety brown with darker brown spotting on the snout, head, flanks and fins. The scales are heavy and ganoid and do not overlap. The snout is long and broad, but not as long as that of the Longnose Gar (*L. osseus*). Lengths of 112 cm and weights of up to 13 kg have been recorded, but more common sizes are in the range of 60 cm.

These fish are usually thought of as obnoxious due to their voracious piscivorous feeding habits. They may, however, play a valuable role in natural control and management through their predation on smaller species.

Distribution

The Spotted Gar is essentially a southern species, occurring in the United States in all of the states bounded by the Gulf of Mexico, but it does extend north into the Mississippi River and Great Lakes drainages (Figure 2).

It occurs in the fresh and brackish waters of the Gulf of Mexico from northern Florida in the east to the Rio Grande River system in northeastern Mexico in the west. In the Mississippi River basin, it has been reported from Mississippi north through Louisiana, Arkansas, Tenessee, Kentucky, Oklahoma, southeastern Kansas, Kentucky, Missouri and to Illinois, Indiana and Michigan. In the Great Lakes basin this species has been reported from Lake St. Clair and Lake Erie.

In Canadian waters the Spotted Gar has been reported in Lake Erie from Long Point Bay, Norfolk County (42° 17′N, 81° 53′W) and at Point Pelee, Essex County (41° 57′N, 82° 31′W). It has also been reported from the St. Clair River and in the Lake St. Clair drainage (Scott and Crossman 1973). In the Lake St. Clair drainage, it has been collected near the mouth of the Thames River, Kent county (42° 19′N, 82° 27′W), (Figure 3).

Protection

The species is afforded no special treatment in law. The fish habitat provisions of the Fisheries Act do, however, offer some protection from potentially harmful industrial and related developments. Ron-

*Rare status approved and assigned by COSEWIC 6 April 1983.

FIGURE 1. Spotted Gar, *Lepisosteus oculatus* (from Scott and Crossman 1973).

deau Bay and Point Pelee populations receive some protection from their locations in, respectively, a provincial and a national park. There is, however, commercial fishing in Rondeau Harbour.

Population Size and Trends

The Spotted Gar usually occurs in small numbers throughout much of its range (Cross 1967; Clay 1975; Pflieger 1975). The Canadian population of Spotted Gar occurs at the northern extremity of its North American range. In Canada, the Spotted Gar is sporadically collected; the most recent reported capture was in 1975 in Rondeau Harbour. Based on Canadian capture records, it is suggested that a small breeding population has existed in Rondeau Harbour. The Ontario Ministry of Natural Resources records show that Longnose Gar are commonly captured in Rondeau Harbour, but Spotted Gar are only infrequently captured. Only sporadic records occur for Spotted Gar elsewhere in the Great Lakes. The continued presence of the Spotted Gar in Canadian waters is unconfirmed. It has likely escaped capture in some areas within its Canadian range due to its solitary nature and lack of sampling in its preferred habitat.

Suitable habitat for Spotted Gar spawning is present along much of the north shore of Rondeau Harbour and a small reproducing population may be present. Similar habitat exists in Long Point Bay and at Point Pelee which are prior capture sites; however, the absence of recent captures in these areas, despite intensive sampling (Ward 1973; Reid 1978; Hamley and MacLean 1979), suggests that breeding populations of this species do not exist, or are extremely small.

The Spotted Gar has been captured in Lake St. Clair very sporadically. The status of sustained populations in Lake St. Clair is unclear; whether specimens obtained represent members from a breeding population, or are transient records from a Lake Erie based population is unknown.

Trautman (personal communication) suggested that this species has become increasingly rare in Ohio waters as a result of habitat degradation and destruction. Shoreline development along the north shore of Lake Erie will, in all probability, have a detrimental effect on areas which now provide suitable gar habitat. Information, gathered from commercial bait dealers and fishermen working in the western basin of Lake Erie, suggests that fishermen experience difficulties in recognizing more than one species of gar, and that all gar are commonly killed when captured because of their piscivorous feeding habits. It is possible that Spotted Gar numbers have been reduced through the Lake Erie commercial fishing industry.

Habitat

Most recorded capture sites in southwestern Ontario were in quiet bays and backwater areas along Lake Erie's north shore, with only one site occurring in Lake St. Clair. Bottom substrates were composed of

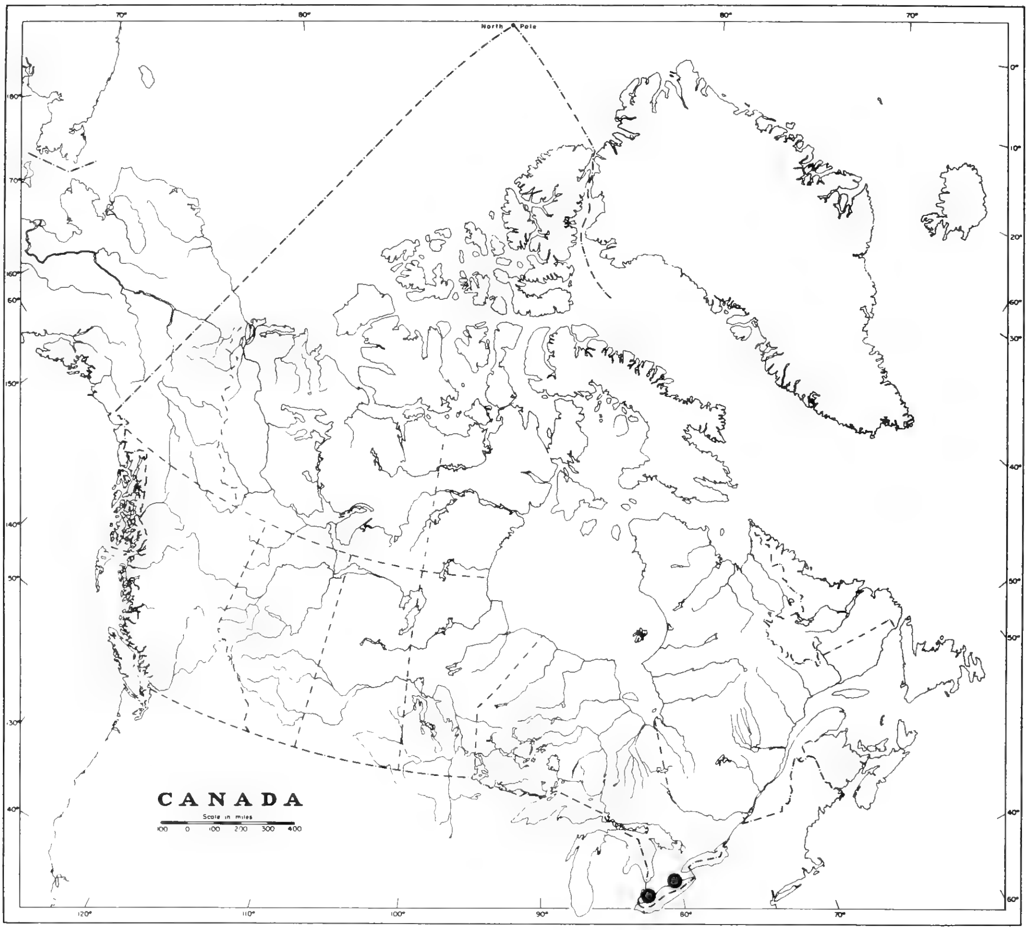

FIGURE 2. Canadian distribution of Spotted Gar (*Lepisosteus oculatus*). Courtesy of D. E. McAllister, National Museum of Natural Sciences.

clays, detritus, and soft muck. A single capture site in Rondeau Bay had a gravel-and-stone bottom devoid of aquatic macrophytes; however, dense aquatic vegetation was present a few hundred meters from the site. Typically, aquatic vegetation was dense at capture sites. Spatterdock (*Nuphar* sp.), Cattails (*Typha* sp.) and Waterweed (*Anacharus* sp.) were abundant. Turbidity varied among capture sites (Secchi disk range from 30 cm to over 3 m) and dissolved oxygen levels ranged from 9 to 11 mg/L at water temperatures from 15° C to 17° C in September. This species is tolerant of warm waters and low dissolved oxygen levels, and can survive in these conditions for a long time (Scott 1967).

General Biology

Much of the pertinent literature states that the biology of the Spotted Gar is similar to that of the Longnose Gar, but no detailed discussions seem to be available (Scott and Crossman 1973).

The Spotted Gar is distinguished from the Longnose Gar by head colour, snout length and lateral line scale count. The Spotted Gar has a spotted head; its snout is wide, least snout width 6 to 8 times in snout length; and lateral line scales vary in number from 53 to 57. The Longnose Gar does not have a spotted head; it has a long, narrow snout, least snout width 14 to 18 times in snout length; and it has a higher lateral line scale count than the Spotted Gar, usually 61 to 65

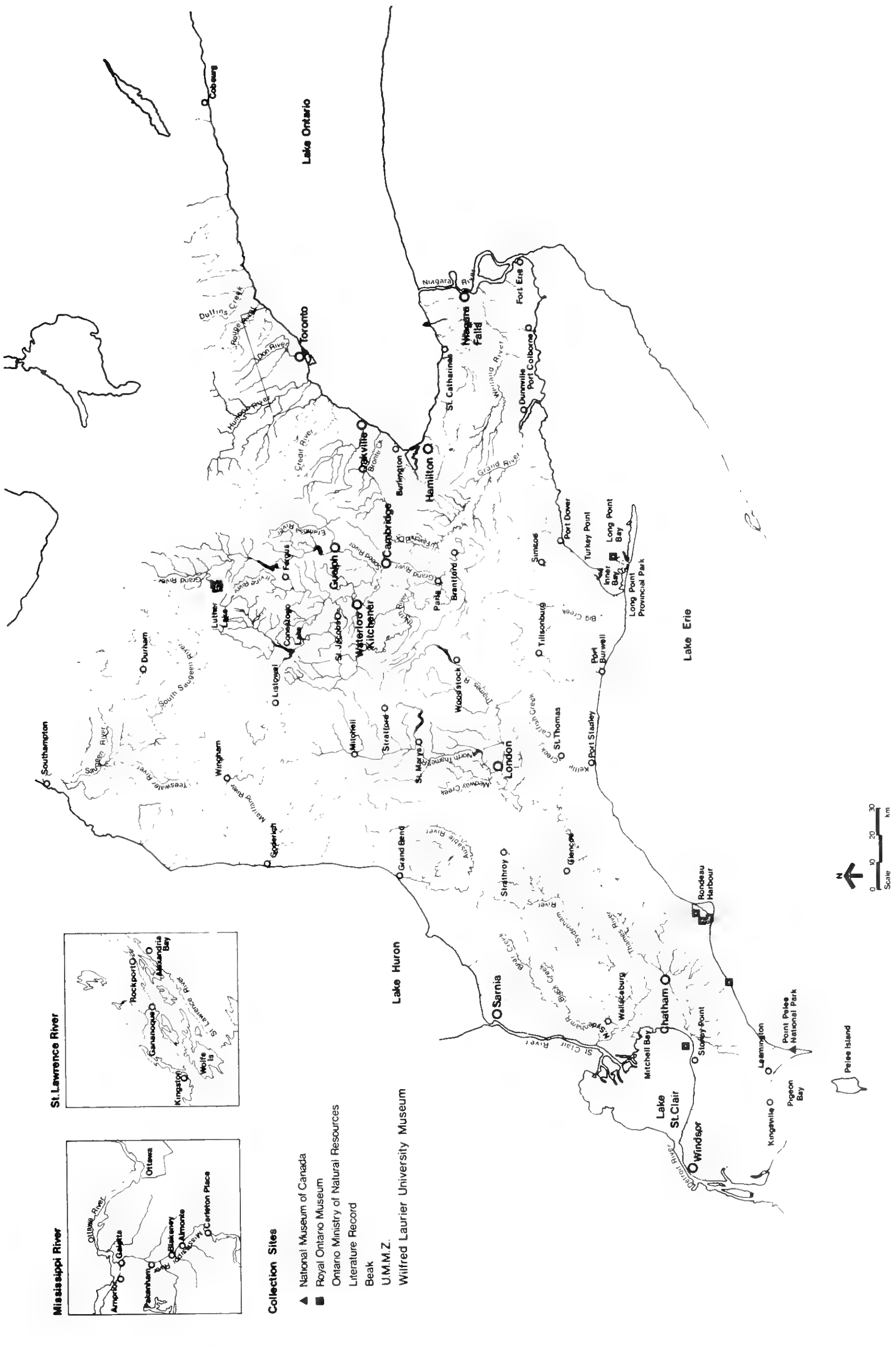

FIGURE 3. Collection records of Spotted Gar (*Lepisosteus oculatus*) in Ontario.

(D. E. McAllister and C. G. Gruchy, personal communication).

Museum specimens of Spotted Gar taken in Canadian waters range from 40 to 66 cm in total length (TL). The average length of these specimens was 57 cm (TL). Canadian specimens were not aged. Trautman (1957) stated that young-of-the-year Spotted Gar in Ohio range in length from 18 to 25 cm (TL), while adults range from 41 to 91 cm (TL) and weigh from 450 to 2270 g. Redmon (1964) reported that one-year-old Spotted Gar in Missouri are approximately 25 cm long and three-year-old fish are about 51 cm long. Linear regressions of length and weight were calculated for Alabama populations for the Spotted Gar by Carlander (1969). Maximum age for this species in Canada is unknown, but Redmond (1964) recorded a maximum age of 18 years in Missouri.

Growth rates for the Spotted Gar have been calculated by Riggs and Moore (1960) for Oklahoma populations; young Spotted Gar grew between 1.4 and 2.1 mm in length and increased between 0.7 to 1.3 g per day during July and August. Redmond (1964) found that male Spotted Gar grow faster than females until age 2, after which females grow more rapidly. Females grow larger, and live longer than males (Scott and Crossman 1973). Pflieger (1975) reported that in Missouri, males mature when they are two or three years old while females do not mature until their third or fourth year.

Spotted Gar are believed to spawn during the spring in Ontario (Scott 1967). Specimens collected from Canadian waters could not be examined during this study to determine their spawning condition. However, published data from more southerly populations may be pertinent. Suttkus (1963) reported that Spotted Gar spawn during the spring in Louisiana, in shallow warm water where aquatic vegetation is abundant. In Missouri, this species was observed spawning in late April, in rapidly flowing waters emptying from an area of flooded timbers (Redmon 1964).

Spawning areas may exist in the inflowing streams of Rondeau Harbour. These streams are heavily vegetated and may be used by the Longnose Gar as spawning areas. Commercial fisherman working in Rondeau Harbour state that during May and June, gar are quite common in the harbour, but are less frequently observed in later months. It is believed that this apparent increase in gar numbers in the harbour may be related to spawning activity.

Virtually nothing is known regarding the actual spawning of the Spotted Gar. Suttkus (1963) stated that spawning adults ranged in length from 552 to 575 mm and that males were generally smaller than females at spawning. Many of the specimens captured in Ontario waters fall into this size range and, therefore, could be considered mature and of spawning potential. Cook (1959) briefly outlined the spawning activity of this species. He states that gar spawn in pairs over aquatic weeds, submerged brush, and debris, spreading semi-adhesive eggs over the bottom materials. Eggs hatch within a week. The larval gar cling to aquatic plants and debris or hang from the surface film by a disc-like maxillary structure.

Spotted Gars are generally considered voracious piscivores. Although factual data on the food habits of this species are limited, it is believed that virtually all fishes that share its warm water habitat may be considered as food for this species (Redmon 1964). Carlander (1969) states that feeding activity is heaviest during the morning. Scott (1967) listed the Yellow Perch (*Perca flavescens*) and minnows (Cyprinidae) as forming a large part of the diet of Spotted Gar in Canada. Redmon (1964) noted that in Missouri the first foods in the diet of young-of-the-year Spotted Gar included mosquito larvae and small crustaceans. Fish were incorporated into the diet of young Spotted Gar at an early age and the Banded Killifish (*Fundulus diaphanus*) was considered one of the primary prey species. Adults fed mostly on Gizzard Shad (*Dorosoma cepedianum*), which made up 90% of their diet, and to a much lesser extent freshwater invertebrates, crayfish and aquatic insects. Both the Gizzard Shad and Banded Killifish were captured in Rondeau Harbour as well as a variety of sunfishes and minnows.

Crabs (*Callinectes sapidus*) are considered a major food item in southern populations of Spotted Gar (Darnell 1958; Lambou 1961); the importance of crustaceans as food items for Spotted Gar in Canada is unknown.

Parasites have not been identified from this species. Hoffman (1967) listed various trematodes, cestodes, nematodes, acanthocephalens and crustacea as parasites of gar.

The Spotted Gar is usually considered an obnoxious fish by commercial and sport fishermen because of its piscivorous feeding habits. Gar are usually destroyed by commercial fishermen and are a favorite species of bow fishermen in some parts of the United States. Their flesh is edible, but is not preferred. Their eggs are toxic to warm-blooded mammals (Pflieger 1975).

Limiting Factors

The Canadian population of Spotted Gar occurs at the northern extremity of its North American range. Although a reproducing population is believed to be present, confirmation is lacking. There is believed to be no immediate threat to the species or its habitat in Canada.

Special Significance of the Species

The species has no commercial significance. Its restricted distribution in Canada, representing the northern limit of the species, places it in a particularly vulnerable position with respect to any habitat changes.

Evaluation

Given that (1) a very small, reproducing population of Spotted Gar may be present in the vicinity of Rondeau Harbour; (2) available information does not allow definitive analysis of population structure; (3) the Canadian population of Spotted Gar occurs at the northern extremity of its North American range; (4) it is unlikely that the Spotted Gar was common in the Great Lakes prior to recorded collections, and (5) the Spotted Gar has become increasingly rare in the Great Lakes basin due to long-term habitat destruction in the northern U.S., it is recommended that the Spotted Gar be classified as a rare species in Canada.

Acknowledgments

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Preliminary Status of the Acadian Whitefish, *Coregonus canadensis*, in southern Nova Scotia*

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Edge, Thomas A. 1984. Preliminary status of the Acadian Whitefish, *Coregonus canadensis*, in southern Nova Scotia. Canadian Field-Naturalist 98(1): 86–90.

The Acadian Whitefish (*Coregonus canadensis*) is a uniquely Canadian species found only in southern Nova Scotia. Anadromous populations have been recorded in the Tusket River and one of its tributaries, the Annis River. Freshwater populations without access to the sea are known from three lakes in the Petite Rivière watershed. In the fall of 1982, two specimens of Acadian Whitefish were collected in the Annis River and 23 were collected from the Petite Rivière watershed. The construction of a hydro-electric power dam on the Tusket River, poaching, overfishing and the acidification of the Tusket and Annis Rivers (average pH's of about 4.7 and 5.0, respectively, in 1982) have contributed to the severe decline of anadromous populations. Acadian Whitefish in the Petite Rivière watershed, while apparently more numerous, may also eventually be threatened by acid precipitation. The Acadian Whitefish is an endangered species requiring immediate attention in order to prevent its extinction.

Endémique au Canada, le corégone d'Acadie (*Coregonus canadensis*) est restreint à la Nouvelle-Ecosse méridionale. Des populations anadromes ont été signalées dans la rivière Tusket et dans un de ses tributaires, la rivière Annis. Des populations dulçaquicoles confinées aux eaux intérieures sont présentes dans trois lacs du bassin versant de la Petite-Rivière. À l'automne 1982, on a capturé deux spécimens dans la rivière Annis et 23 dans le bassin de la Petite-Rivière. Suite à la construction d'un barrage hydro-électrique sur la rivière Tusket, au braconnage, à la surpêche et à l'acidification des rivières Annis et Tusket (où le pH moyen s'élève respectivement à environ 5,0 et 4,7), les populations anadromes ont chuté. Les populations du bassin versant de la Petite-Rivière, quoique apparemment plus nombreuses, sont aussi menacées par les pluies acides. Cette espèce est menancée d'extinction et on doit porter une attention immédiate afin d'en prévenir la disparition. [Traduit par R. R. Campbell]

Key Words: Nova Scotia, Milipsigate Lake, whitefish, distribution, habitat, population size and trends, endangered.

Whitefish have been captured accidentally by anglers and some commercial fishermen in Nova Scotia for many years. However, it was not until the 1950-1960's that whitefish in two areas (Tusket River watershed, Yarmouth County, and Petite Rivière watershed, Lunenburg County) were discovered to be unique. Scott (1967) gave an account of this new species under the name Atlantic Whitefish, *Coregonus canadensis*. He found that it (Figure 1) differs from the Lake Whitefish (*Coregonus clupeaformis*), also found in some Nova Scotia lakes, in a number of characters: particularly in having a terminal mouth, smaller scales (91-100 in lateral line compared to 70-85 on Lake Whitefish) and in having small but well-developed teeth on the premaxillaries, palatine and vomer. Legendre (1978) proposed the name Acadian Whitefish for the species.

Distribution

The Acadian Whitefish is known only from southern Nova Scotia (Figure 2). An anadromous population recorded from the Tusket River (Scott and Crossman 1973). Verbal reports of freshwater populations without access to the sea were known from Milipsigate Lake in the Petite Rivière watershed (Lunenburg Co.). Specimens have been captured in seawater from Yarmouth Harbour (Yarmouth Co.) and at Halls Harbour (Kings Co.). Verbal accounts related to the Acadian Whitefish suggested that the species was extinct. However, a field survey conducted from 16 September 1982 to 20 November 1982 found anadromous Acadian Whitefish surviving in the Annis River, a tributary of the Tusket River, and landlocked populations in Minamkeak, Milipsigate and Hebb Lakes in the Petite Rivière watershed.

Protection

The Nova Scotia Fishery Regulations under section 34 of the Fisheries Act were amended 17 February 1970, to prohibit the taking of Atlantic Whitefish from all waters of the province by any method at any time of the year. The habitat of the Acadian Whitefish is protected in the Petite Rivière watershed. Minamkeak, Milipsigate and Hebb Lakes provide the domestic and industrial water supply to the town of Bridgewater (population 6010 in 1976) and these lakes and their tributaries have been designated as a Protected Water Area (Lunenburg County District Planning

*Endangered status approved and assigned COSEWIC 10 November 1983.

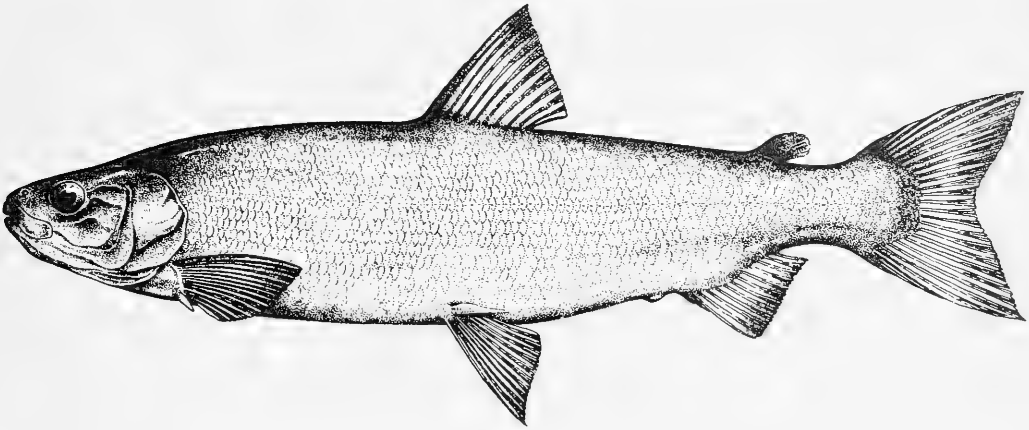

FIGURE 1. Acadian Whitefish (*Coregonus canadensis*). Courtesy D. E. McAllister, National Museum of Natural Sciences.

Commission 1980). Except for a few private lakeshore landholdings, all swimming, boating, and lakeshore development is prohibited on these lakes. While this gives a measure of protection against lakeshore activity and pollution of local origin, it does not protect against airborne pollution such as acid rain. The poaching of a number of fish species has been a serious problem in the past in the Tusket River area (D. Atkins, personal communication). To date, there has been little effort to monitor fishways during Acadian Whitefish migrations and to control the whitefish poaching which probably persists to a limited degree in the Tusket River area and in Milipsigate Lake.

Population Size and Trends

There have been no studies on the population size of the Acadian Whitefish; as a result there are no reliable estimates of how many survive. Gillnetting results from the Petite Rivière watershed suggested that population levels are low. Average catches of 0.75, 1.25 and 2.0 whitefish per 75 m gillnet set for 18 hours were obtained in Milipsigate, Minamkeak and Hebb Lakes respectively.

Local residents, fishermen, and fishery officers indicate the Acadian Whitefish was abundant in the past during its anadromous migrations in the Tusket and Annis Rivers. John Gilhen (*Ms.* Report on the status of the Atlantic Whitefish, *Coregonus canadensis*, in the Tusket River watershed, Yarmouth County, Nova Scotia, including recommendations to ensure its future survival [1977]. 18 pp.) reported commercial fishermen commonly caught 50 to 100 whitefish each year in Gaspereau (*Alosa pseudoharengus*) nets on the Annis River. After the construction of a hydro-electric dam on the Tusket River, one local resident remembered seeing men pitchforking whitefish from the fish ladder into trucks for use as fertilizer in nearby fields (W. B. Scott, personal communication). Little is known of the historical background of the Acadian Whitefish in the Petite Rivière watershed. Piers (1927) first reported whitefish from angler catches in Milipsigate Lake in the early 1920's.

At present, a small anadromous population of Acadian Whitefish survives in the Annis River. Two specimens were caught during our survey in the fall of 1982 in this river. Fishermen on the Annis River have been getting a combined catch of fewer than 10 whitefish each year for roughly the last 10 years and even these small catches are apparently declining.

The Acadian Whitefish population in the Tusket River is, at best, dangerously low and may have virtually disappeared. Incidental catches of whitefish in the gaspereau fishery, once common, are now extremely rare. There were no whitefish captures in a trap net monitored by the Department of Fisheries and Oceans on the Tusket powerhouse fish ladder from 8 October 1982 to 20 November 1982, although there was only limited attraction water from this fish ladder (D. Atkins, personal communication). This was the only functioning fish ladder at the Tusket River hydro-electric dam in the fall of 1982. The Tusket River holding dam fish ladder was almost dry in the fall of 1982 and the old fish ladder at the powerhouse dam is now obstructed to prevent poaching.

In the Petite Rivière watershed, four experimental gill nets (each 75 m in length with 15 m panels of stretched mesh sizes of 25, 37.5, 50, 75, and 100 mm) were set overnight in Minamkeak, Hebb, and Fancy

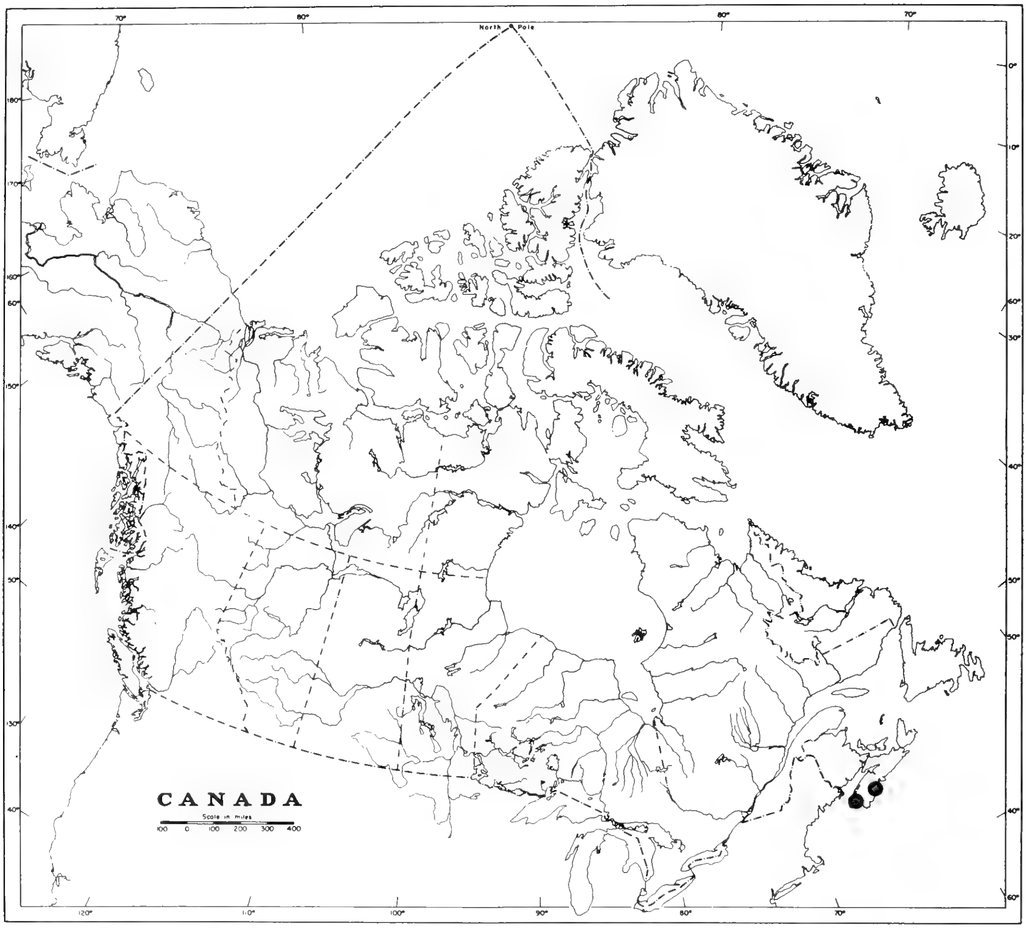

FIGURE 2. Distribution of Acadian Whitefish in Canada. Courtesy D. E. McAllister, National Museum of Natural Sciences.

Lakes and over three nights in Milipsigate Lake. Acadian Whitefish accounted for 7.0%, 6.4% and 2.1% of the specimens of all species in Minamkeak, Hebb and Milipsigate Lakes respectively. The reports of whitefish from Milipsigate Lake in the early 1920's, would suggest there is a small, reproducing population at least in this lake at present.

Habitat

Very little is known of the habitat requirements of the Acadian Whitefish. Verbal reports and available catch information suggest that the anadromous populations do not penetrate into freshwater to any great distance. The distribution of these populations in the marine environment is unknown. Within lakes in the Petite Rivière watershed, Acadian Whitefish were distributed throughout the water column from the surface down to 11 m and were mostly confined to open water during the fall of 1982. The Petite Rivière has been obstructed by dams without fishways for at least 150 years and there are no known reports of anadromous whitefish from this river.

There have been a number of detrimental alterations of the natural habitat within the Tusket River watershed over the past 60 years. The Tusket River hydro-electric dam, built in 1929, has a history of ineffective fish ladders on the powerhouse dam and the nearby holding dam. It has also drastically altered the appearance of the watershed and caused extensive water level fluctuations. The Lake Vaughn reservoir,

contained by the Tusket River dam, was drained in the fall of 1981 and again in the summer of 1982 to install and subsequently repair doors on the new holding dam.

Probably the most serious reduction in available habitat for the Acadian Whitefish has been the result of the acidification of the Tusket River. The Tusket is one of at least seven rivers in southern Nova Scotia which will not support successful reproduction of Atlantic Salmon, *Salmo salar* (Farmer et al. 1980). In 1982, the Tusket and Annis Rivers had average pH's of about 4.7 and 5.0 respectively (W. Watt, personal communication).

The Petite Rivière watershed occupies an area of Nova Scotia where bedrock and soil conditions are more capable of buffering acid precipitation. This river had an average pH of about 5.5 in 1981 (W. Watt, personal communication). Water levels are known to fluctuate in this watershed (the water level in Milipsigate Lake dropped about 50 cm from a maximum depth of about 11 m between 28 September 1983 and 6 November 1982) but changes are not likely to be as drastic as in the Tusket River. While habitat changes in this watershed have been comparatively slow, the Petite Rivière may be susceptible to acid precipitation in the future.

General Biology

Virtually nothing is known of the reproductive capabilities of the Acadian Whitefish. This species is believed to spawn in the fall or early winter, although exact dates and locations of spawning are unknown. Pearl organs, known to develop on breeding males, were observed on specimens from the Annis River and Hebb Lake caught on 12 October and 12 November respectively. The Acadian Whitefish in Milipsigate Lake have evidently survived a limited angling effort and any predation due to the piscivorous White Perch (*Morone americana*), American Eel, (*Anguilla rostrata*), and Yellow Perch (*Perca flavescens*) present in this lake, since at least the 1920's.

The Acadian Whitefish is anadromous in the Tusket and Annis Rivers. Local residents, fishermen, and fishery officers have reported this whitefish to move upstream from about mid-September to early November. It overwinters in freshwater and returns to the marine environment from about mid-February to late April. Two specimens were caught moving upstream in the Annis River on 12 and 13 October respectively. While the Acadian Whitefish is known to move out of the Tusket River estuary, its subsequent movements in salt water are unknown.

It is not known if Acadian Whitefish were anadromous in the Petite Rivière at one time or whether they were always confined to freshwater. Local anglers report this whitefish aggregates to feed just above and below the dam outlet of Milipsigate Lake at the beginning of May. There is now a reasonable road access to this dam providing easier access for poaching.

Little is known of the behavior or adaptability of the Acadian Whitefish. Scott and Crossman (1973) report that specimens from salt water in Yarmouth Harbour had stomach contents of amphipods, small periwinkles, and marine worms. Local anglers report that in Milipsigate Lake this whitefish feeds on aquatic insect larvae and is readily taken in the spring on a baited hook or a fly, often leaping from the water once caught. Absolutely nothing is known of the spawning or young of Acadian Whitefish.

Limiting Factors

In the past the Tusket and Annis rivers simultaneously supported large populations of Atlantic Salmon and Acadian Whitefish, possibly due to the different time periods for anadromous migrations. This point may be worthy of note for any attempts to transplant anadromous Acadian Whitefish to avoid their extinction.

The construction of the Tusket River hydro-electric dam in 1929, with its ineffective fish ladders, greatly disrupted Acadian Whitefish spawning migrations and exposed the fish to severe overfishing. The newest fish ladder on the Tusket powerhouse dam was built in 1979 and is used by Gaspereau and salmon but its effectiveness for whitefish is unknown. These fish ladders are difficult for fish to find when there is little attraction water.

Incidental whitefish catches in the gaspereau fishery and poaching were significant in the past in the Tusket River area. These sources of whitefish mortality continue, although to a much lesser extent in recent years.

Successful introductions of the Chain Pickerel (*Esox niger*), Brown Trout (*Salmo trutta*) and Lake Whitefish, (*Coregonus clupeaformis*) have occurred in southern Nova Scotia. In the fall of 1982, five Chain Pickerel (three of large size) were caught in Salmon Lake, the first lake on the Annis River. One Brown Trout was caught on 9 October migrating up the Annis River. There is also an extensive Brook Trout (*Salvelinus fontinalis*) stocking program in Nova Scotia. The impact of the introduction of these potential predators and competitors of the Acadian Whitefish is unknown. It may be noted that the introduction of the Cisco (*Coregonus artedi*) was associated with a serious decline in population levels of the Opeongo Whitefish (*Coregonus* sp.) in Opeongo Lake in the Province of Ontario (D. E. McAllister, B. J. Parker, and P. M. McKee. *Ms.* Rare endangered and extinct fishes in Canada). These introductions have not

occurred in the Petite Rivière watershed and this watershed is one of the few in Nova Scotia that has not had introductions of Brook Trout (T. Goff, personal communication).

The expansion of the present distribution of Acadian Whitefish appears highly unlikely. Almost every major river in southern Nova Scotia has been obstructed by dams at some point along its course. While these obstructions are gradually being removed, many rivers are becoming increasingly acidic as a result of acid precipitation. There are few large, unobstructed watersheds with good acid buffering capacity in Nova Scotia that might prove suitable for transplanting anadromous Acadian Whitefish in order to prevent their extinction.

Special Significance of the Species

The Acadian Whitefish is of special significance for the following reasons:

1) it is one of the few fish species endemic to Canada and the only one endemic to Nova Scotia;
2) it has recreational potential, being an exciting gamefish;
3) it is the only uniquely Canadian fish ever featured on a postage stamp.

Evaluation

The construction of the Tusket River hydro-electric dam with subsequent overfishing and the more recent acidification of the Tusket and Annis Rivers have contributed to the serious decline of anadromous populations of the Acadian Whitefish. The Acadian Whitefish populations in the Petite Rivière watershed appear less threatened although the continued acidification of this watershed warrants concern. At present, the population size, biology and ecological requirements of this species are poorly known and in need of immediate study.

Due to the limited distribution of the species, low numbers, and immediate threats to its habitat, the species is considered to be in danger of extinction.

Acknowledgments

The author would like to thank the Federal Department of Fisheries and Oceans for financial support. Don McAllister of the National Museum of Natural Sciences, generously made available his time and facilities throughout the project. Richard Dittmann provided untiring field assistance while braving the untourist-like conditions often encountered. Also appreciated was the assistance of Brian Coad and Len Marhue of the National Museum of Natural Sciences, John Gilhen of the Nova Scotia Provincial Museum, and W. B. Scott, Dick Cutting, Doug Atkins, Trevor Goff and W. D. Watt of the Federal Department of Fisheries and Oceans. My thanks also to Limon Earl, Jim Hatfield and A. Raymond for providing verbal insights on the species.

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Status of the Silver Shiner, *Notropis photogenis*, in Canada*

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Parker, B., and P. McKee. 1984. Status of the Silver Shiner, *Notropis photogenis*, in Canada. Canadian Field-Naturalist 98(1): 91–97.

The Silver Shiner (*Notropis photogenis*) is rare in Canada. It occurs in Lake Erie tributaries and the Ohio and Tennessee River watersheds in the United States. This species was first found in Canada in 1971; it occurs in the Grand and Thames River watersheds of southwestern Ontario. The Canadian populations may be long established and long separated from American populations. Canadian populations are locally abundant and currently appear to be stable or increasing and reproducing. American populations have decreased in this century. The Silver Shiner inhabits medium to large streams with moderate to high gradients and hard bottoms; spawning habitat is unknown. Canadian habitat quality has probably declined. Growth appears to be rapid and maximum length reported in Ontario was 10.85 cm. Most Silver Shiners matured during their second summer. The species is primarily a surface feeder but is not highly specialized in its diet. Limiting factors are not yet known, but stream gradient and water quality may be affecting distribution and abundance. It is recommended that the Silver Shiner be classified as a rare species in Canada. There is high potential for maintenance of the Canadian populations.

Le méné-miroir, *Notropis photogenis*, est rare au Canada, où sa présence a été signalée pour la première fois en 1971 dans les bassins des rivières Grand et Thames, au sud-ouest de l'Ontario. Aux États-Unis, il peuple les tributaires du lac Erié, et les bassins des rivières Ohio et Tennessee. On croit que les populations canadiennes se sont établies et séparées des populations américaines depuis longtemps. Les premières sont abondantes localement, et semblent être stables ou croissantes, tandis que les secondes ont diminué au cours du siècle. Ce poisson peuple les cours d'eau moyens à grands de pente modérée à forte où le substrat est dur. On ignore tout des frayères. La qualité des habitats canadiens a probablement diminué. La croissance semble rapide et la longueur maximale signalée en Ontario est de 10.85 cm. La majorité atteint la maturité sexuelle au cours du deuxième été. Il se nourrit à la surface, mais son régime alimentaire n'est pas très sélectif. On ne connaît pas encore de facteurs limitatifs, mais la pente des cours d'eau et la qualité de l'eau peuvent influer sur sa répartition et son abondance. On recommande que le méné-miroir reçoive le statut d'espèce rare au Canada. Il existe des possibilités élevées de survie des populations canadiennes. [Traduit par R. R. Campbell]

Key Words: Southwestern Ontario, cyprinids, rare, distribution, population size and trends.

The Silver Shiner (*Notropis photogenis*) is a fluviate species of large clear streams (Trautman 1957) and has only recently been found in Canada, in southwestern Ontario (Gruchy et al. 1973). The Silver Shiner (Figure 1) is a small cyprinid similar to the Rosyface Shiner (*Notropis rubellus*) or the Emerald Shiner (*Notropis otherinodes*). The fish are silvery but may show olivaceous colouring dorsally and silver-white vertically. Breeding individuals may show red colouration on the head. The body is slender and elongate, rarely exceeds 60–70 mm in length, and is moderately compressed.

The species may have some importance as a forage or bait species for larger fishes and could be useful in studies of water quality determination.

Distribution

The following account is based primarily on the spot distribution map of Gilbert (1980) and is supplemented by information collected by Parker and McKee (1980). In the United States, the Silver Shiner is found throughout most of the Ohio River basin in West Virginia, western New York and Pennsylvania, Ohio, Indiana, and Kentucky, although it is absent in the western lowlands section of the Ohio River. This species also occurs in the upper Tennessee River watershed in the Appalachian Mountains. In the Great Lakes basin the Silver Shiner is found in tributaries of Lake Erie in Ohio, Indiana and Michigan. Trautman (1957) stated that there had been no obvious recent change in the limits of the species range. In Ohio its distribution remained essentially the same between 1854 and 1950 although it "must have been present . . . in the Ohio River before that stream was impounded and when it was less turbid and less polluted" (p. 343).

The Silver Shiner was not known in Canada until 1971 (Gruchy et al. 1973). It is now known to occur in the Lake Erie and Lake St. Clair drainages of Ontario (Figure 2). In the Grand River watershed of Ontario, the Silver Shiner occurs in the Grand, the Conestogo, and the Nith rivers. Grand River specimens have been collected from seven km south of Elora, Wellington Co. (43° 37′25″N, 80° 27′00″W) to Brantford, Brant

*Rare status approved and assigned by COSEWIC 6 April 1983.

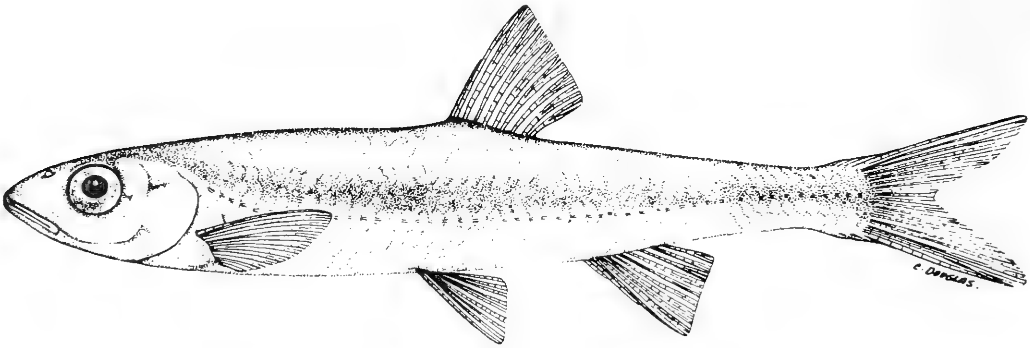

FIGURE 1. Silver Shiner (*Notropis photogenis*). Courtesy of D. E. McAllister, National Museum of Natural Sciences.

Co. (43°08′30″N, 80°17′20″W). In the Conestogo River, this species occurs in the lower stretch of the river below the dam at St. Jacobs, Waterloo Co. (43°32′10″N, 80°34′25″W). Nith River specimens were taken near Ayr, Waterloo Co. (43°17′40″N, 80°28′13″W) (Figure 3).

In the Lake St. Clair drainage, the Silver Shiner population is apparently centered near the city of London, Middlesex Co., in the Thames River watershed. All specimens were collected within an eight km radius of the city centre (42°59′22″N, 81°14′57″W): from the North Thames River, from Medway Creek, and from the Thames River both upstream and downstream of the North Thames confluence (Figure 3).

Protection

No specific protection for the Silver Shiner now exists in Canada, although the fish habitat section of the Fisheries Act does afford general protection.

Population Size and Trend

The Silver Shiner was found to be locally abundant in the Grand and Thames River watersheds by Parker and McKee (1980). Their 1979 catches averaged 37 Silver Shiners per 100 m^2. Densities were not constant. While schools of Silver Shiner occurred in areas of moderate current and eddies below dams, several sampling stations in the Grand and Thames River watersheds which seemed to provide suitable habitat provided few or no specimens. The species was rare in, or absent from, smaller tributary streams and slow-flowing sections of the main rivers.

The first collections of Silver Shiners in Canada in 1971 and the continuing presence of the species suggest an increase in numbers prior to or during the early 1970's. A recent invasion of the Grand River by this species is improbable since large areas of unsuitable habitat separate this Ontario watershed from the nearest populations in the United States (Gruchy et al. 1973; Parker and McKee 1980). It is also unlikely that Silver Shiners were introduced by sport fishermen since these fish survive only for short periods in bait buckets. Earlier specimens may have been confused with Rosyface Shiners as reported by Trautman (1957). The popularity of the Silver Shiner as a bait fish in the Grand River watershed and the ability of fishermen to distinguish the species (Parker and McKee 1980) suggest a long-established population of this species there.

The Silver Shiner was not discovered in the Thames River watershed until 1974 (Parker and McKee 1980) and this population is apparently restricted to the London area. There are insufficient data to determine whether this represents a relict or a recently established population.

Former low population levels may at least partially account for the fact that Silver Shiners were not detected in Ontario until recently. Similarly, this species was only recently found in Ohio's Grand River after many years of sampling (Parker and McKee 1980) and was not taken in Michigan between 1942 and 1952 (Gruchy et al. 1973).

The data thus appear to indicate a currently stable or increasing Silver Shiner population in Ontario, but there are insufficient data to indicate any trend in distribution. The Silver Shiner decreased considerably in numbers in many Ohio localities between 1920 and 1950 (Trautman 1957). It is generally uncommon to rare in Lake Erie tributaries (Gilbert 1980) but was apparently decreasing in numbers in those tributaries in 1970 (Van Meter and Trautman 1970). In Michigan, the Silver Shiner was considered to have changed from rare status to threatened (Miller 1972).

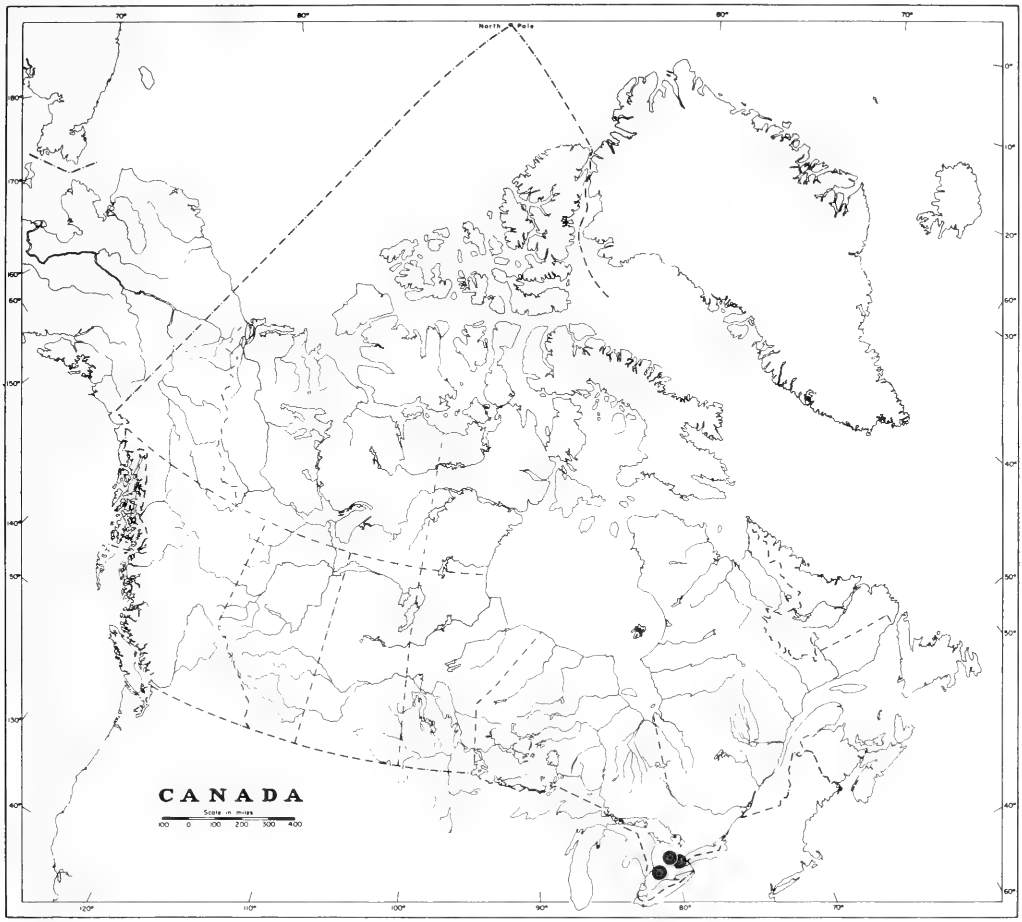

FIGURE 2. Canadian Distribution of the Silver Shiner (*Notropis photogenis*). Courtesy of D. E. McAllister, National Museum of Natural Sciences.

Habitat

The Silver Shiner inhabits medium to large streams with moderate to high gradients, and thus, medium to fast currents (Trautman 1957; Gruchy et al. 1973; Gilbert 1980). Average gradient was 1.4 m/km over the species' Grand River range, 1.4 m/km in the Nith River, 1.9 m/km in the Conestogo River, and 0.5 to 1.4 m/km in the Thames River (Parker and McKee 1980).

Stream widths at capture sites during the 1979 work by Parker and McKee (1980) ranged from 5 to 100 m, but only two sites had widths of less than 30 m. Alternating pools and riffles characterized most sites. Large numbers were also taken in turbulent waters below dams. All specimens were taken in stream sections ranging between 20 and 100 cm in depth; deeper waters were not sampled during this survey. Gruchy et al. (1973) captured Silver Shiners at depths of 75 to 100 cm. Trautman (1957), Gruchy et al. (1973), and Gilbert (1980) stated that this species usually occurs over gravel to boulder bottoms. In Ontario, the Silver Shiner was found mainly over pebble and cobble bottoms with occasional boulders and areas of gravel, sand and silt (Parker and McKee 1980). Large numbers were also taken over uniform concrete aprons below dams.

Trautman (1957) and Gilbert (1980) stated that this species avoids rooted aquatic plants. Gruchy et al

(1973) captured Ontario specimens at sites with some submergent vegetation. Parker and McKee (1980) found macrophytes abundant at some capture sites and absent at others, with no apparent correlation between plant abundance and catch per unit effort of Silver Shiners.

Trautman (1957) found that Silver Shiners were most abundant in streams "which had relatively clear waters throughout most of the year" (p. 343). They inhabit the least turbid Lake Erie tributaries (Van Meter and Trautman 1970). However, the four capture sites of Gruchy et al. (1973) had cloudy or muddy water. Specimens were captured by Parker and McKee (1980) in clear and green-tinged water with low levels of turbidity. Dissolved oxygen and temperature levels ranged from 8.5 to 13 mg/l and 20 to 23.5°C, respectively, in late summer 1979. Within its Grand and Thames River ranges, Silver Shiner distribution is localized. There are too few data as yet to explain this distribution in terms of habitat or to define critical habitat such as spawning areas.

At a general level, the sections of the Grand and Thames River watersheds inhabited by the Silver Shiner have variable, but not high, water quality. The surrounding areas are largely agricultural and most of the land has been cleared of forest. London, Kitchener, Waterloo, Cambridge, Brantford and several smaller urban centres are located on the rivers inhabited by the Silver Shiner. Following heavy precipitation, suspended solid levels can increase considerably due to erosion of the intensively farmed soils in the region. Wong and Clark (1976) found wide diurnal fluctuations in dissolved oxygen concentrations in southern Ontario streams. However, the intensive use of these watersheds has existed for some time, so that the recent trend in the general quantity and quality of habitat is likely a slow reduction.

It is impossible at present to identify trends or rates of change in any critical habitat factors. Population trends in the United States suggest decreasing numbers in response to decreasing habitat quality. In Ohio, Trautman (1957) found that "During the 1920-50 period the species decreased markedly in numbers in many localities, especially in those portions where turbidity and siltation had increased greatly." (p. 343). He suggested that the species' absence from some rivers was due to turbidity, pollution or impoundments. Current habitat conditions in Canada do not appear to be the preferred conditions of the species. Further deterioration carries the risk of population decreases.

General Biology

Little information has been published on the age and growth of Silver Shiners, and the scale method of age determination has not been validated for this species. In August and September, Parker and McKee (1980) found that young-of-the-year ranged from 3.5 to 5.9 cm (standard length) and 0.7 to 2.5 g (preserved weight), 1+ fish were 5.5 to 7.7 cm (SL) and 2.1 to 4.9 g and 2+ fish 8.7 to 9.8 cm (SL) and 6.7 to 12.5 g. Only one 3+ specimen (8.8 cm (SL), 9.1 g) was examined, suggesting that most individuals have a maximum age of three winters. Gruchy et al. (1973) reported that juveniles were 3.25 to 5.45 cm long (SL) and that adults were 5.70 to 10.85 cm long (SL) in late July and early August. Trautman (1957) gave lengths of 3.8 to 6.1 cm for young-of-the-year captured in October, 5.1 to 7.6 cm for one-year-olds, and 6.9 to 10.9 cm for adult Silver Shiners in Ohio. These data suggest that growth is rapid, particularly during the first year, and that the growth rate is similar in Ontario and Ohio. There are no data on relative abundance of age groups, or on sex ratios, in any populations.

Few investigations of reproduction in Silver Shiners have been documented. Most Ontario Silver Shiners mature during their second summer (Parker and McKee, 1980). One-quarter of specimens less than 5.5 cm long (SL) had maturing gonads. All specimens longer than 6 cm (SL) were mature. These observations suggest that a few Silver Shiners may spawn at age one but most spawn at age two. Breeding males have very small tubercles on the upper surface of the pectoral fins, on the head, and on the scales of the anterior part of the body (Trautman, 1957). Silver Shiners spawn in the Grand River during mid-June (Parker and McKee, 1980). Specimens captured on 4 June 1980 were in pre-spawning condition. Water temperatures averaged 17°C. On 24 June 1980 many spent adults were captured. Water temperatures averaged 23°C. Hybridization occurs rarely with the Common Shiner (*Notropis cornutus*) (Trautman 1957), indicating that the Silver Shiner also spawns during late spring or early summer (Parker and McKee 1980).

Actual spawning sites in the Grand River watershed are not known but deep flowing stretches over 1 m deep were suspected to be spawning areas. Available data indicate that Silver Shiner populations in the Grand and Thames River watersheds are reproducing, but do not indicate reproductive rate. Populations appear to be stable or increasing suggesting that reproduction is at least replacing mortality.

There are no data on movements of Silver Shiners. The failure to find spawning fish by Parker and McKee (1980) may indicate that the fish move to spawn. The largest concentrations of Silver Shiners found by Parker and McKee (1980) were below dams. The species normally occurs in schools (Trautman, 1957), and most Ontario schools were composed of individuals of all length classes (Parker and McKee 1980).

Gut content analysis by Parker and McKee (1980)

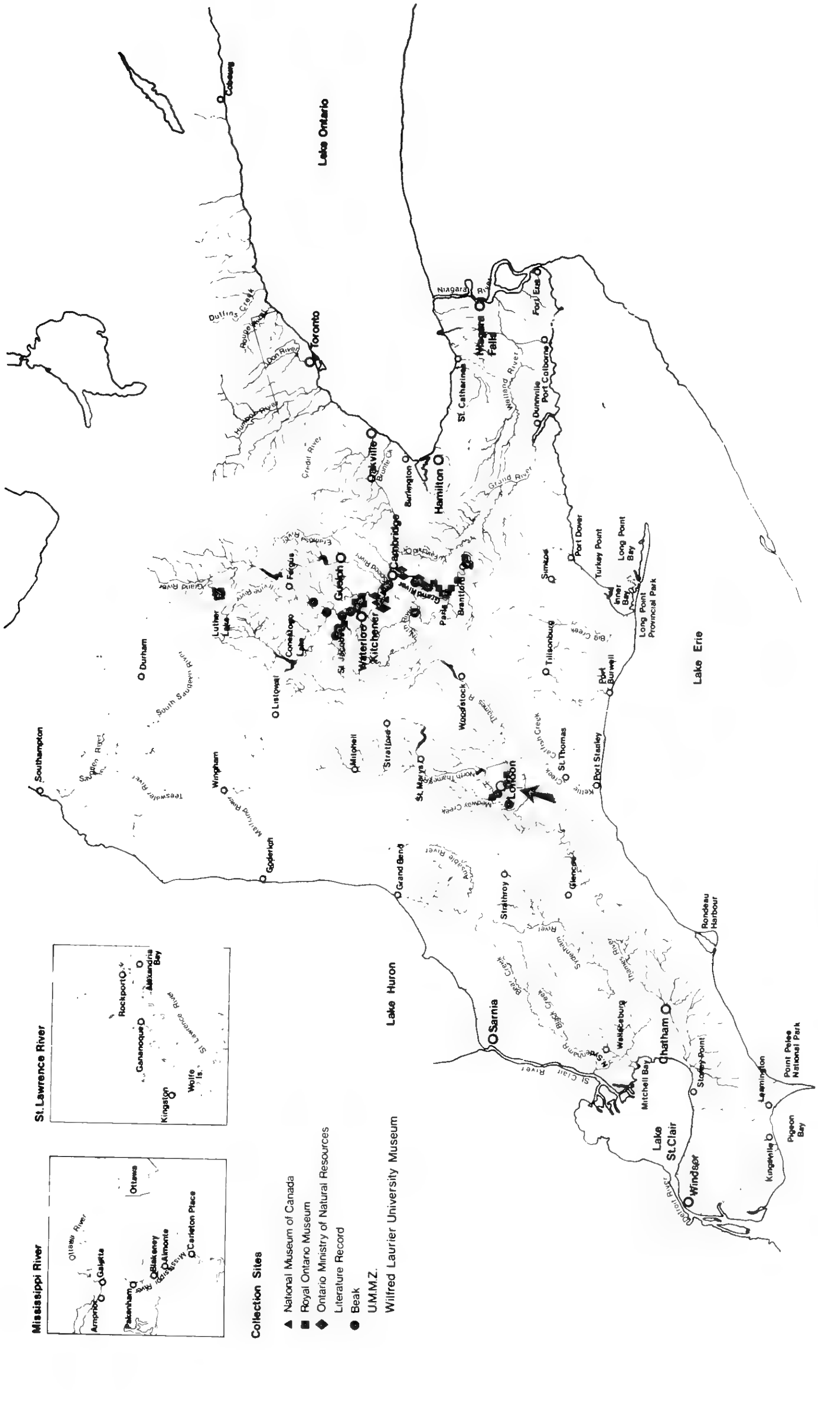

FIGURE 3. Collection records of *Notropis photogenis* in Ontario.

indicated that the Silver Shiner is primarily a surface feeder. Insects comprised more than 90 per cent of the volume of identifiable gut contents. Adult Diptera were present in three-quarters of the specimens examined and accounted, on average, for more than half of the total identifiable volume. The presence of large volumes of immature aquatic insects in many specimens indicated that benthic organisms are also important in the diet. Smaller quantities of nematodes, microcrustaceans, hydrachnids, and filamentous algae were found. There was considerable variation in gut contents among specimens, indicating that the Silver Shiner is an opportunistic feeder. Gruchy et al. (1973) examined the stomachs of nine specimens from the Grand River and found the diet to be composed primarily of adult and larval insects, with two turbellarians in one stomach. Trautman (1957) reported that Silver Shiners may jump into the air to capture flying insects.

Silver Shiners are not highly specialized feeders, although they may be characterized as surface feeders. The data are insufficient to assess their degree of habitat or spawning-site specialization.

Silver Shiners are tolerant of some degree of human disturbance, since they survive and have perhaps recently increased in abundance in the agricultural and urban Grand and Thames River watersheds. They have however, decreased in the United States. The rate of response of the species to habitat changes is unknown. Its susceptibility to special conditions such as fluctuating water levels or severe winters is also unknown.

Limiting Factors

There are insufficient data to identify limiting factors for the Silver Shiner. Habitat loss, environmental contamination or other aspects of human disturbance are possible factors, and turbidity, pollution, or impoundments may have been responsible for population declines in Ohio. Stream gradient appeared to limit the distribution of the Silver Shiner in the Grand River watershed (Parker and McKee 1980). Over the range of this species in the Grand River, the average gradient was 1.4 m/km. An abrupt drop in average gradient to less than 0.3 m/km, in downstream sections beginning immediately below Brantford, corresponded with the downstream limit of the distribution of the Silver Shiner. An increase in gradient to 5.7 m/km through the Elora Gorge appeared to impose an upstream limit to its range. Average gradients over the Silver Shiner's range in the Nith and Conestogo Rivers were 1.4 and 1.9 m/km, respectively. In the Thames River watershed, the Silver Shiner was collected only from London where average gradients ranged from 0.5 to 1.4 m/km.

Species competition is a possible limiting factor. Silver Shiners appear to inhabit only some of the available habitat within their Ontario range (Parker and McKee 1980). There is no evidence to suggest that predation is limiting, but it is also a possible factor. A Smallmouth Bass (*Micropterus dolomieui*) was observed seizing a large Silver Shiner in the Grand River, and Rock Bass (*Ambloplites rupestris*) were suggested as possible predators by Parker and McKee (1980).

Parasites are unlikely to be limiting. Silver Shiner specimens collected in Ontario showed no external evidence of parasitic infestation (Parker and McKee 1980). Berra and Au (1978) reported very few cysts of the black-spot trematode (*Uvilifer*) in this species suggesting that the fast-flowing water inhabited by Silver Shiners discourages the attachment of the free-swimming larval parasite. Hoffman (1967) reported infestation of this species by the trematode (*Neodactulogyrus*).

Man's use of the Silver Shiner in Ontario is limited, but many anglers favour this species as a bait minnow for warm water game fish in the Grand River watershed (Parker and McKee 1980).

Special Significance of the Species

The Silver Shiner does not occur outside the United States and Canada. It was considered threatened in Michigan by Miller (1972) but not in any other states.

The genus *Notropis* cannot be considered threatened in any way, but Miller (1972) lists 29 *Notropis* species as threatened in at least one state and many *Notropis* species in the United States have very small ranges (Lee et al. 1980).

The degree of public interest in this species is low. However, there is a concern by a number of groups for rare, threatened or endangered species in general. Some interest by fishermen exists through their use of the species as bait.

The Ontario populations are the most northern for the Silver Shiner. They are distinct from the rest of the range, and are of scientific interest as possibly genetically different because they have been subject to different climatic influences.

Evaluation

The Canadian distribution is naturally limited and cannot be expected to expand significantly. Apparently stable or increasing reproducing populations of Silver Shiners are present in the Thames and Grand River watersheds, and the species does not currently appear threatened in Canada due to the actions of man. Limiting factors are not yet known, but gradient and water quality may be affecting distribution and abundance. It is recommended that the Silver Shiner be classified as a rare species in Canada.

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Editor's note: Subsequent to the submission and acceptance of this status report further research has been completed and its publication is pending:

Baldwin, Mary Elizabeth. 1983. Habitat use, distribution, life history and interspecific association of *Notropis photogenis* (Silver Shiner; Osteichthyes: Cyrinidae) in Canada, with comparisons with *Notropis rubellus* (rosyface shiner). M.Sc. thesis, Carleton University, Ottawa.

Status of the Speckled Dace, *Rhinichthys osculus*, in Canada*

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Peden, A. E., and G. W. Hughes. 1984. Status of the Speckled Dace, *Rhinichthys osculus*, in Canada. Canadian Field-Naturalist 98(1): 98–103.

Specked Dace (*Rhinichthys osculus*) have a restricted Canadian distribution along a 70 mile (112 km) section of the Kettle and Granby Rivers, British Columbia. Although the species is widely distributed in seven western American states, the species has differentiated into a number of distinct populations. Some populations are considered rare or endangered by the American Fisheries Society's Committee on Endangered Species. The Canadian population seems to have adequate reproductive capacity and is not endangered as long as its habitat in the Kettle River is not adversely altered. As yet, there are not enough observations to indicate cyclical fluctuation of population size as occurs in some American populations. The recent finding of another species of dace that apparently replaces Specked Dace below Cascade, British Columbia, indicates that the Canadian population may be isolated from other American populations.

Au Canada, le naseux moucheté (*Rhinichthys osculus*) se retrouve sur 70 milles (112 km) dans les rivières Kettle et Granby, en Colombie-Britannique. Bien qu'elle soit largement répartie dans sept Etats de l'Ouest américain, l'espèce s'est différenciée en un certain nombre de populations distinctes dont quelques-unes sont considérées comme rares ou menacées d'extinction par les Comité sur les espèce menacées d'extinction de l'American Fisheries Society. Pour sa part, la population canadienne semble avoir une bonne capacité de reproduction et ne sera pas en danger tant que son habitat de la rivière Kettle sera maintenu en bon état. Les donnés actuellement disponibles ne sont pas suffisantes pour nous indiquer si le niveau de la population varie de manière cyclique, comme c'est le cas pour certaines population des Etats-Unis. [Traduit par R. R. Campbell]

Key Words: Pacific northwest, Columbia River, cyprinids, dace, rare, distribution, population size and trends

The Speckled Dace (*Rhinichthys osculus*) is a small cyprinid restricted to Western North America. In Canada it has been found only in the Kettle River of the Columbia system (Scott and Crossman 1973). These are elongate fish (Figure 1) of about 50-70 mm in length with bodies robust anteriorly and compressed laterally behind the dorsal fin. They are of grey or grey-brown colour with some darker flecks usually above the midline. There is a faint lateral band terminating in a diffuse spot at the base of the caudal fin. Vertically, the fish are lighter in colour, varying from creamy-white to yellow (Scott and Crossman 1973).

Speckled Dace enjoy some importance as a forage species and are often used as bait fish. In Canada, its importance is minimal due to its limited distribution.

Distribution

Speckled Dace are known as a number of highly variable populations distributed between the Colorado drainage in Arizona and the Columbia River system in the Pacific Northwest (Minckley 1973; Scott and Crossman 1973). The species has morphologically differentiated in many isolated river drainages. The Kettle River of the Columbia River system is the northern limit of the species, recorded geographic range (Figure 2). Within Canada, Speckled Dace have been taken along a 112 km stretch of the East and West Kettle River from Carmi, British Columbia, to Cascade at the U.S./Canadian international border, and along a 27 km section of the Granby River above Grand Forks. Speckled Dace have not been found in other tributaries of the Kettle River system in Canada (Figure 3).

Our survey, made while drifting down the river across the international border at Cascade in 1980, suggests Speckled Dace do not occur much farther downstream. Below Cascade, waterfalls probably hinder upstream dispersal of fish. The habitat for the next couple of miles down the river changes from rocks and boulders to a finer-sedimented pebble, sand, or mud bottom on which adult dace were not found. Juvenile Speckled Dace were found, but they decreased in abundance and were replaced by juveniles of another species of dace, possibly *R. umatilla*. At the first rock or boulder habitat encountered, about 5 miles downstream in Washington State, large numbers of adults of this "*umatilla*" form were encountered and no Speckled Dace observed. Even though we did not go farther downstream in Washington, we believe the Canadian Speckled Dace population is largely isolated within Canada (except for the mid-portion of the Kettle River (Figure 3) which criss-crosses back into Washington State). It is unlikely to

*Rare status approved and assigned by COSEWIC 6 April 1983.

FIGURE 1. Speckled Dace (*Rhinichthys osculus*). Courtesy of D. E. McAllister, National Museum of Natural Sciences.

recover by upstream immigration or gene flow from Washington State if the Canadian population should be decimated. Similar forms of Speckled Dace might occur in downstream tributaries of the Kettle and Columbia Rivers; however, we have not investigated them. Quite possibly, ecological exclusion of Speckled Dace, through competition with the "*umatilla*"-like dace may prevent contact between Canadian and other American Speckled Dace populations. Speckled Dace would obviously be swept over the falls at Cascade during floods, etc., but we believe that waterfalls plus ecological exclusion are strong impediments to upstream dispersal.

Protection

There are no formal measures specifically adminstrated or legislated to protect Speckled Dace. Maintenance of water quality standards and prevention of silting are the major factors of importance to its future survival.

Population Size and Trends

Peden and Hughes (1981) found Speckled Dace widely distributed between Carmi and Cascade, British Columbia, but juveniles far outnumbered adults in the samples taken. Adults were found in sections of river with rock habitat and moderately strong current where siltation and scouring of the river bottom was not excessive. Although small juveniles were widely distributed, concentrations of larger juveniles and adults were mostly found below the waterfalls at Cascade, in the Granby River at Grand Forks, and in a pile of boulders at Carmi. We believe that there is a high mortality of juveniles, particularly during the period of spring floods, and only those fish finding suitable habitat survive to be adults. Early sampling has been insufficient to determine population trends, however, our surveys in 1978, 1979, and 1980, indicate the population to be stable. Even though we observed few adult habitats, we believe that there are many more in sections of the river to which we did not have access. In other parts of its geographic range, Speckled Dace are subjected, and apparently adapted, to irregular but severe flooding, and population size changes drastically with these catastrophies.

Habitat

During the spring of 1978, a large flood of melted snow-water characterized all Kettle River drainages, preventing us from observing or collecting *R. osculus*. With only about 3 per cent of this flow occurring in the fall (October), fish were much more easily caught and we believe that *R. osculus* must adapt to a general scouring of the river bed with each spring flood followed by a slow receeding of the water at the river's edge during summer and fall. Most of the Granby River that is inhabited by juvenile dace is characterized by a clean sand bottom with little algae or other vegetation. In contrast, most of the Kettle River where juveniles were captured had innumerable smooth stones without extensive debris or organic growth and a slow to moderate flow of water. A very thin scum of aglae covered the stones along the river's edge where the water was less than 0.25 m deep. Higher up the river banks, dried and encrusted algal mats were observed indicating some algal growth occurred earlier in the year before flood waters had receeded. Such accumulations of vegetation and detritus are most likely swept away during each spring flood.

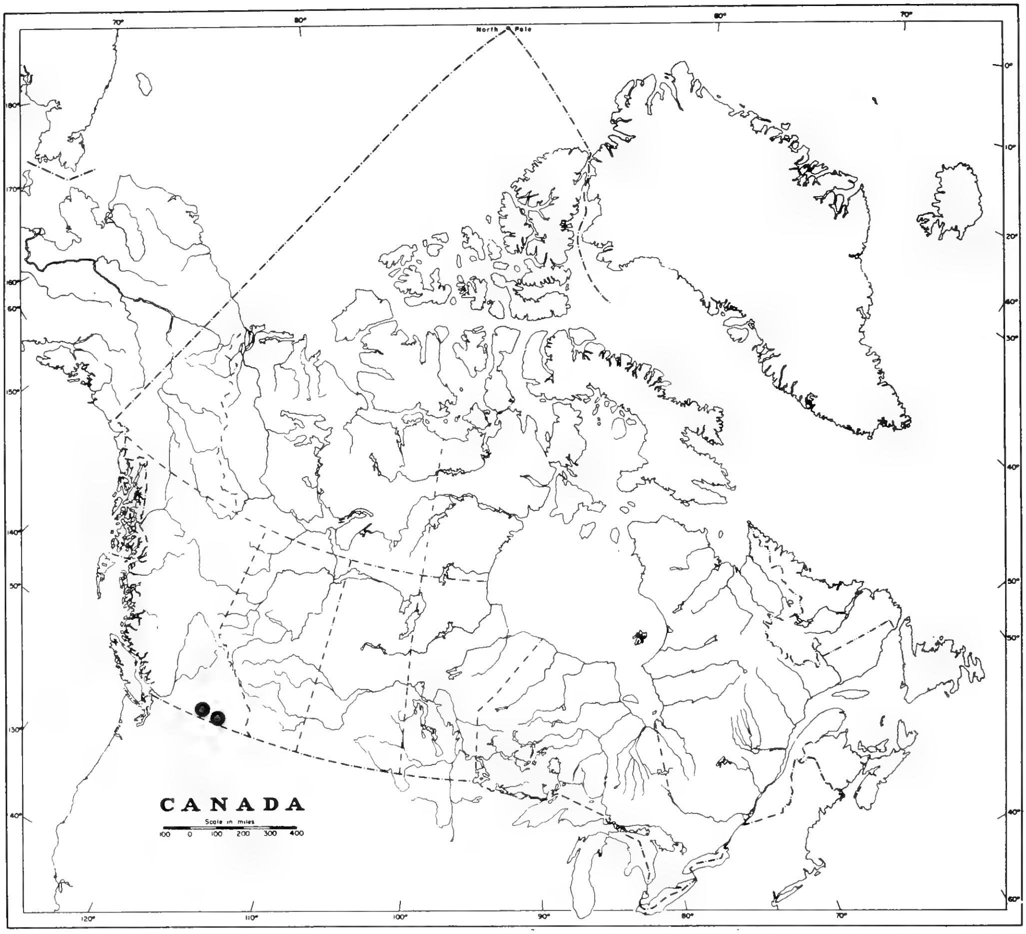

FIGURE 2. Canadian distribution of Speckled Dace (*Rhinichthys osculus*). Courtesy of D. E. McAllister, National Museum of Natural Sciences.

As might be expected of rivers which rise from mountainous areas and are fed by melting snow, gradual warming of the water occurs as it flows to lower elevations. Upstream, where Speckled Dace were found at Carmi (elevation approximately 884 m), average summer water temperatures reached 14°C, but downstream at Laurier, just across the international border from Cascade, British Columbia, (elevation approximately 457 m), water temperatures reached almost 18°C. Between 16 March 1965 and 25 September 1978, the Province of British Columbia's Water Investigation Branch (unpublished data) recorded very clear water in the Kettle River with average Jackson Turbidity Units (on a scale of 0-1000) being between 1.0 and 4.0. Spring runoff, however, could be expected to be more turbid. Generally, dissolved solids (as indicated by alkalinity) increase (60 to 77.5 mg/L) and pH decreases (8.7 to 7.7), as water flows downstream. Small amounts of dissolved solids (e.g. average alkalinity 37.3 mg/L) characterize the entire study area of the Granby River.

For reasons to be described later, we believe the small fish under 40 mm S.L. (= Standard Length) are no more than 1½ years old. Larger and presumably older fish (above 40 mm) were infrequently seen and seemed to inhabit interspaces of large rocks of

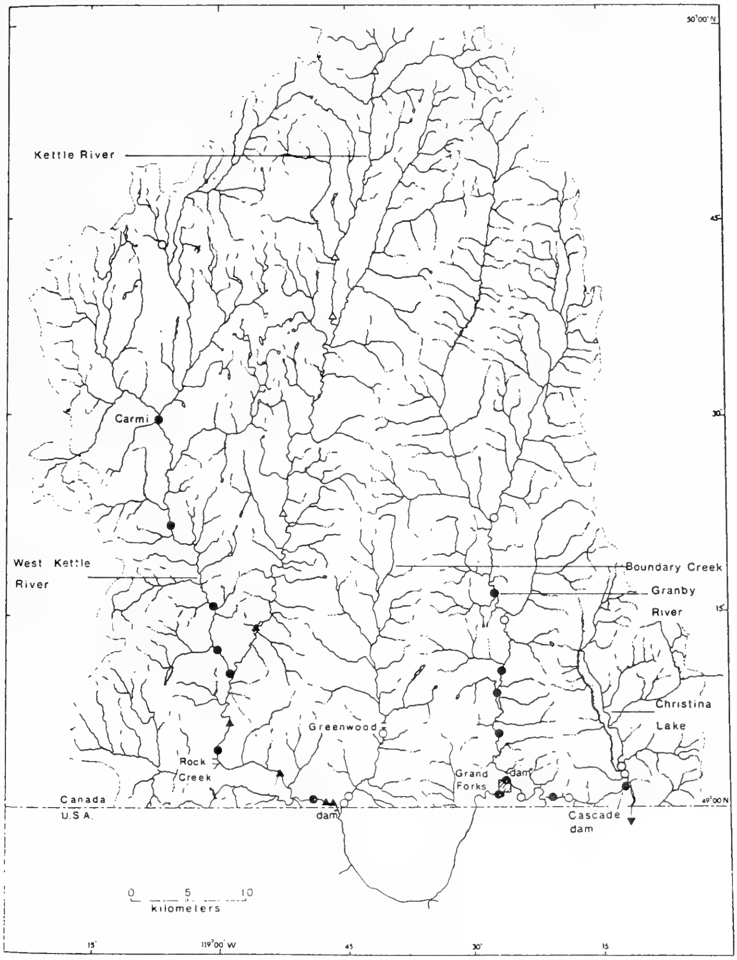

FIGURE 3. Map of Kettle River drainage showing five major tributaries. Collections made by the authors in 1977 are indicated by circles and those from other institutions by triangles. Solid circles or triangles indicate presence of *R. osculus* in a sample and hollow circles or triangles indicate their absence.

approximately 40+ cm diameter where there was a moderate current. Adults were taken in October of 1978, 1979, and 1980, at the mouth of the Granby River in Grand Forks where electrofishing forced fish from an overhanging shaded bank with thick growths of an aquatic moss *Fontinalis sp.*, and where the current was much stronger than that frequented by juveniles. Adults were also taken from amongst large rocks below the falls at Cascade and more were found in a large mound of stones near Carmi where the current was similarly swift.

General Biology

Our examination of length frequencies indicates that fall-caught specimens were smaller than those caught in spring (Peden and Hughes 1981) and corresponding study of egg sizes indicates that Speckled Dace do not mature at least until they are 40, possibly not until 50 mm, in standard length. The data also suggests that Speckled Dace probably spawn in summer (July?) and juveniles hatched in summer probably do not breed until they are two years of age.

Judging by prevalence of young fish, reproductive

potential seems to be high. Numbers of large eggs in ovaries of fall-caught dace ranged from about 450 in small fish to 2000 in large fish. July-caught fish had fewer eggs which may indicate a more prolonged spawning, or that some ova may have been resorbed. We believe there is a single ovarian cycle each year. For the most part, Speckled Dace appear to have more than an adequate reproductive potential to repopulate the Kettle River.

Our samples indicated many fewer males than females (Peden and Hughes 1981). This may result from habitat preference by males for swifter water that we did not effectively sample. Such preference has been suggested by other workers for American populations.

Widoski and Whitney (1979) suggest Speckled Dace do not live long after their first spawning at two years of age but may occasionally reach three years of age. Such observations are based on populations occurring in California, Wyoming, or elsewhere, and not the Kettle River stock. Other than the use of length frequency, which shows at least two size classes (with first-year fish being under 40 mm S.L.), there has been no adequate study on longevity of Kettle River stocks.

Limiting Factors

We have no base-line observations over a long period of time to document habitat loss. As we noticed an absence of dace immediately below Grand Forks, there may be an effect from the town's sewage treatment plant or other sources. One section of the Kettle River criss-crosses the American border and we have no information on potential dangers in Washington State. Logging, road construction, and agriculture could cause siltation or chemical contamination. There are many inactive coal mines at Grand Forks and Greenwood, but we can not determine their past effect on Speckled Dace. Any dam construction would flood riffle or rock habitats and thus eliminate habitat.

Except for sculpins (Cottidae) and juvenile suckers (Catostomidae), we believe there are relatively few competitors with the essentially bottom-living Speckled Dace; however, large numbers of the schooling and presumably mid-water-feeding Red Shiner (*Richardsonius balteatus*) and Northern Squawfish (*Ptychocheilus oregonensis*) were also taken in the same samples. The strongest potential competition is probably from the "*umatilla*"-like dace (*Rhinichthys sp.*) which seem to replace Speckled Dace below Cascade.

The effectiveness of waterfalls at Cascade in preventing upstream migration is not yet documented although we believe it is a strong impediment. We, therefore, can not predict whether the "*umatilla*" population is isolated from upstream populations of Speckled Dace by the falls, whether each species is adapted to different factors operating in different sections of the river, or whether "*umatilla*" would replace Speckled Dace if dispersed upstream. Speckled Dace are most likely swept downstream after each spring flood but obviously do not out-compete "*umatilla*" in the lower Kettle River.

Although terrestrial and aquatic predators occur in the area, Speckled Dace habitually hide or retreat under rocks and we do not anticipate severe predation. Physical conditions, such as severe flooding, may even be a more important factor.

Special Significance of the Species

Five races of this polymorphic species are considered endangered or threatened (Deacon et al. 1979): *R. o. lethoporus* (Independence Valley Speckled Dace), *R. o. nevadensis* (Ash Meadows Speckled Dace), *R. o. oligoporus* (Clover Valley Speckled Dace), *R. o. thermalis* (Kendall Warm Springs Dace), and *R. o. moapae* (Moapa Speckled Dace).

Bond (1973) differentiates Speckled Dace from "*umatilla*" in Oregon. Unpublished data indicates that overall body shape, pigmentation, and fin shape of Kettle River specimens readily differentiates the two species. *Rhinichthys "umatilla"* is more likely to be confused with *R. falcatus*, a species common in other nearby river drainages of British Columbia. Both forms are considered subspecies of *R. falcatus* by Bond (1973). Speckled Dace in the Kettle River may represent a unique taxon in Canada. The discovery of the sympatric congener "*umatilla*" in the lower Kettle River at Cascade indicates two populations of distinct species status. This "*umatilla*"-like dace is also found in the Similkameen drainage of British Columbia and apparently does not represent a hybrid between Speckled Dace and *R. falcatus* as suggested by Carl, Clemens and Lindsey (1959) and Scott and Crossman (1973), although sympatry and relationships of "*umatilla*" with *R. falcatus* in Canada has not yet been determined.

Evaluation

We consider Speckled Dace could be threatened in Canada only because its restricted distribution leaves it vulnerable to any catastrophic event affecting a single drainage system. If present habitat and water quality is maintained, there should not be any unnatural decline in the population. Because the population could go through natural population cycles due to different levels of spring flooding, monitoring of population size after unusual flood conditions, etc., would be useful in predicting the population's future status.

At the present time, the status for this species should be "rare".

Acknowledgments

We would like to thank J.D. McPhail for his advice on Speckled Dace problems and Linda Gregory who provided water quality data on the Kettle River. Gordon Greese and Brent Coole assisted in field collections.

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Status of the Spotted Sucker, *Minytrema melanops*, in Canada*

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Parker, B., and P. McKee. 1984. Status of the Spotted Sucker, *Minytrema melanops*, in Canada. Canadian Field-Naturalist 98(1): 104–109.

The Spotted Sucker (*Minytrema melanops*) is rare in Canada but ranges through much of central and eastern North America. In Canada, it is known only from southwestern Ontario in the drainages of Lake Erie and Lake St. Clair. Since the first Spotted Sucker was captured in Canada in 1962 from Lake St. Clair, only nine specimens have been reported from Canadian waters, the most recent in April 1980. Little is known of its biology in Canadian waters, although several studies have been carried out in the U.S. portion of its range.

L'aire de répartition du meunier tacheté (*Minytrema melanops*), s'étend sur la plus grande partie du centre et de l'est de l'Amérique du Nord. Au Canada, il n'a été signalé que dans le bassins de drainage des lacs Erié et Sainte-Claire (Ontario) et c'est dans ce dernier lac qu'il a été capturé pour la Première fois en 1962. Depuis, seulement neuf autres spécimens ont été pêchés en eaux canadiennes, dont le dernier en avril 1980. La répartition de l'espèce dans le sud-ouest de l'Ontario est restreinte et peu de données sont disponibles sur sa biologie au Canada, bien qui plusieurs études aient été menées aux Etats-Unis. [Traduit par R. R. Campbell]

Key Words: Ontario, Lake Erie, Lake St. Clair, suckers, rare, population size and trends, distribution.

The Spotted Sucker (*Minytrema melanops*) is a medium-size sucker usually 230-280 mm in length and not exceeding 1 kg in body weight (Figure 1). Younger fish resemble the White Sucker (*Catostomus commersoni*) but become shaped more like the redhorse with age (Scott and Crossman 1973). The dorsal surface is dark green to brown and the sides bronze to silver and the vertical surface white and silvery. The name arises from the dark spot at the base of each scale. These fish have only been known in Ontario since 1962 (Crossman and Ferguson 1963).

The young fish are preyed on by other fish and birds and the flesh is suitable for human consumption. They are neither a serious competitive threat to other species, nor are they economically important as a forage species or to commercial interests.

Distribution

The Spotted Sucker is restricted to the freshwaters of central and eastern North America. This species occurs throughout much of the Mississippi River basin from Louisiana in the south to Minnesota and Wisconsin in the north, and east in the Ohio River drainage to Ohio, Michigan and Pennsylvania. It is found along the Gulf Coast from the Colorado River drainage in eastern Texas to the Swannee River drainage in Florida. The Spotted Sucker is also recorded along the Atlantic Coast from Georgia to North Carolina. In the Great Lakes basin the Spotted Sucker occurs in the drainages of Lake Michigan, Lake Huron, Lake St. Clair and Lake Erie (Figure 2).

In Canada, the Spotted Sucker has a limited distribution in southwestern Ontario (Figure 3). It has been reported from Lake St. Clair, in Lot 2, Kent County (42° 21′N, 82° 25′W), and near the mouth of the Thames River, Essex County (42° 19′N, 82° 27′W), and (42° 19′N, 82° 25′W). It has entered the East Sydenham River and has been collected south of Wallaceburg, Kent County (42° 35′42″N, 82° 21′30″W) and south of Alvinston, Middlesex County, (42° 46′05″N, 81° 50′00″W). Collections in Lake Erie are restricted to the western basin, the only specific locality being off Point Pelee, Essex County (41° 57′N, 82° 45′W) (Figure 3).

The infrequent occurrence of this species in Canadian waters led Scott and Crossman (1973) and McAllister and Gruchy (1977) to state that the Spotted Sucker is rare within its Canadian range. Elsewhere, this species is considered endangered in Maryland, and has disappeared from much of its range in Illinois (Gilbert and Burgess 1980). It is also becoming less numerous in Ohio (M. B. Trautman, personal communication) and Kansas (Cross 1967).

Protection

There is no specific protection for the species in law. The fish habitat provisions of the Fisheries Act provide general protection from industrial and related developments.

*Rare Status approved and assigned by COSEWIC 6 April 1983.

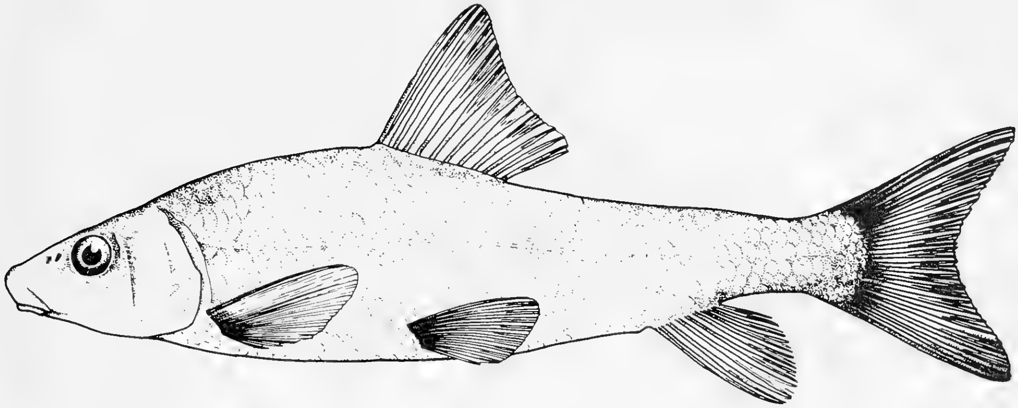

FIGURE 1. Spotted Sucker (*Minytrema melanops*). Courtesy of D. E. McAllister, National Museum of Natural Sciences.

Habitat

In Canada, the Spotted Sucker has been captured in lake and sluggish river environments. Trautman (1957) noted that this species has been captured in lakes, rivers, oxbows, sloughs and streams in Ohio. Elsewhere, it has been collected in all types of slow flowing water bodies from intermittent streams to large lakes and impoundments (Douglas 1974).

Bottom substrates at Spotted Sucker capture sites in Ontario range from hard clays to sand, gravel, and rubble. Pflieger (1975) reported this species was found over soft organic bottoms, but it is generally considered to prefer firm to hard substrates (Cross 1967; Gilbert and Burgess 1980).

The Spotted Sucker has been reported from water bodies with dense aquatic macrophyte growths (Cross 1967); however, records from Canadian collections of this species lack habitat data and the relationships between this species and aquatic macrophytes cannot be substantiated.

The Spotted Sucker prefers clear, warm waters where turbidity is minimal (Trautman 1957). This species has been captured in the East Sydenham River where turbidity is moderate to heavy (Secchi disc approximately 45 cm). The Spotted Sucker is more tolerant to siltation than some other catostomids, especially if siltation is only intermittently heavy (Miller and Robinson 1973). Trautman (1957) stated that this species was found in water bodies where siltation was extremely low. He suggested that the closely-bound gill covers in this species make it tolerant to turbid waters, pollutants and flocculent clay silt substrates. Cross (1967) suggested that the habitat of the Spotted Sucker was especially vulnerable to unfavourable change (mainly siltation) because of intensive cultivation along low gradient streams that are preferred by this species. Oxygen and temperature tolerances are not known for the Spotted Sucker.

General Biology

This species is distinguished from other catostomids in Canada by its distinctive colour pattern, consisting of eight to ten horizontal rows of black spots, one per scale, extending over the whole body length beyond the head (Scott and Crossman 1973).

Adult Spotted Suckers average 230 to 280 mm in length (Scott and Crossman 1973). Ontario specimens average 367 mm in total length (TL), considerably longer than that reported by Scott and Crossman (1973). The smallest Canadian specimen was 275 mm (TL), the largest 440 mm (TL) and weighed 1235 g. Scales from two large specimens, 358 mm and 373 mm (TL) were aged at 7 and 8 years respectively. The maximum age reported for this species in populations from the United States appears to be six years (Carlander 1969).

Trautman (1957) reported that young-of-the-year Spotted Suckers taken in Ohio during October, ranged in length from 5.1 to 10.2 cm. Adults ranged from 22.9 to 38.1 cm in length and weighed between 170 and 794 g. The largest specimen from Ohio measured 450 mm in length and weighed 1361 g. Dwarf forms were reported by Trautman (1957) but growth data were not included for these fish. Pflieger (1975) stated that Spotted Suckers in Oklahoma attain a length of about 15.5 mm in the first year and average 29, 34, 41, and 44 cm at the end of succeeding years. Data on growth rates between sexes have not been published.

Age of maturity is not known for Canadian popula-

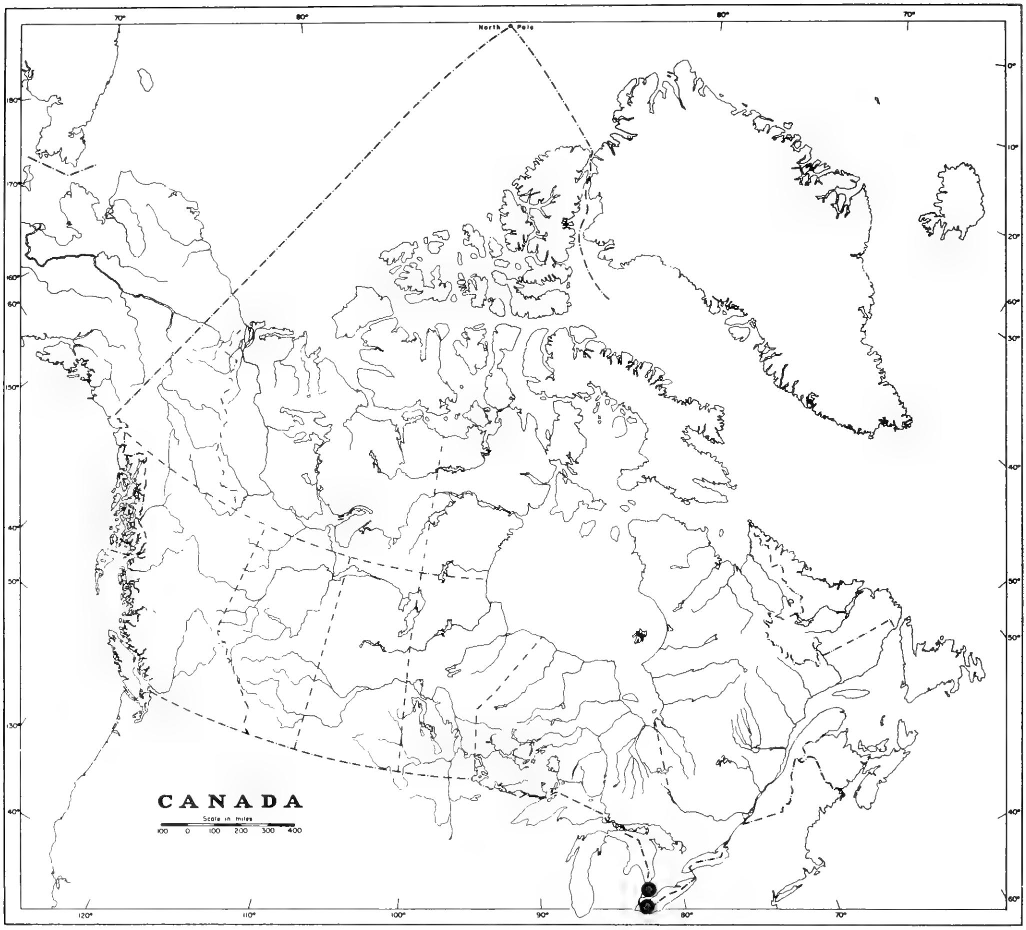

FIGURE 2. Canadian Distribution of the Spotted Sucker (*Minytrema melanops*). Courtesy of D. E. McAllister, National Museum of Natural Sciences.

tions, but a female in breeding condition, captured 1 April, in the Thames River was aged at five years. Pflieger (1975) reported that Spotted Suckers in Missouri reached maturity at age 3. Dwarf forms captured in Ohio are reported to mature at a length of 150 mm (Trautman 1957).

The Spotted Sucker spawns during late spring or early summer. The single female specimen captured in April was in prespawning condition. The water temperature at the time of capture was 7° C. Tuberculated males have been recorded in early June in Ohio (Trautman 1957). McSwain and Gennings (1972) reported that spawning took place in Georgia Creeks in waters ranging from 12 to 19°C. McSwain and Gennings (1972) also stated that spawning Spotted Suckers were observed in riffle areas over coarse limestone rubble where the water depth averaged 40 cm. The flow rate in the rifle area was estimated at 1.4 m^3/sec. Depressions behind large rocks were often used as spawning sites. Spawning groups of Spotted Suckers observed in Georgia consisted of three individuals, two males and one female. The ratio of males to females on the spawning grounds was estimated at 1:1. Spawning activity was described by McSwain and Gennings (1972). They observed semi-buoyant eggs drifting downstream after a union. Observations sug-

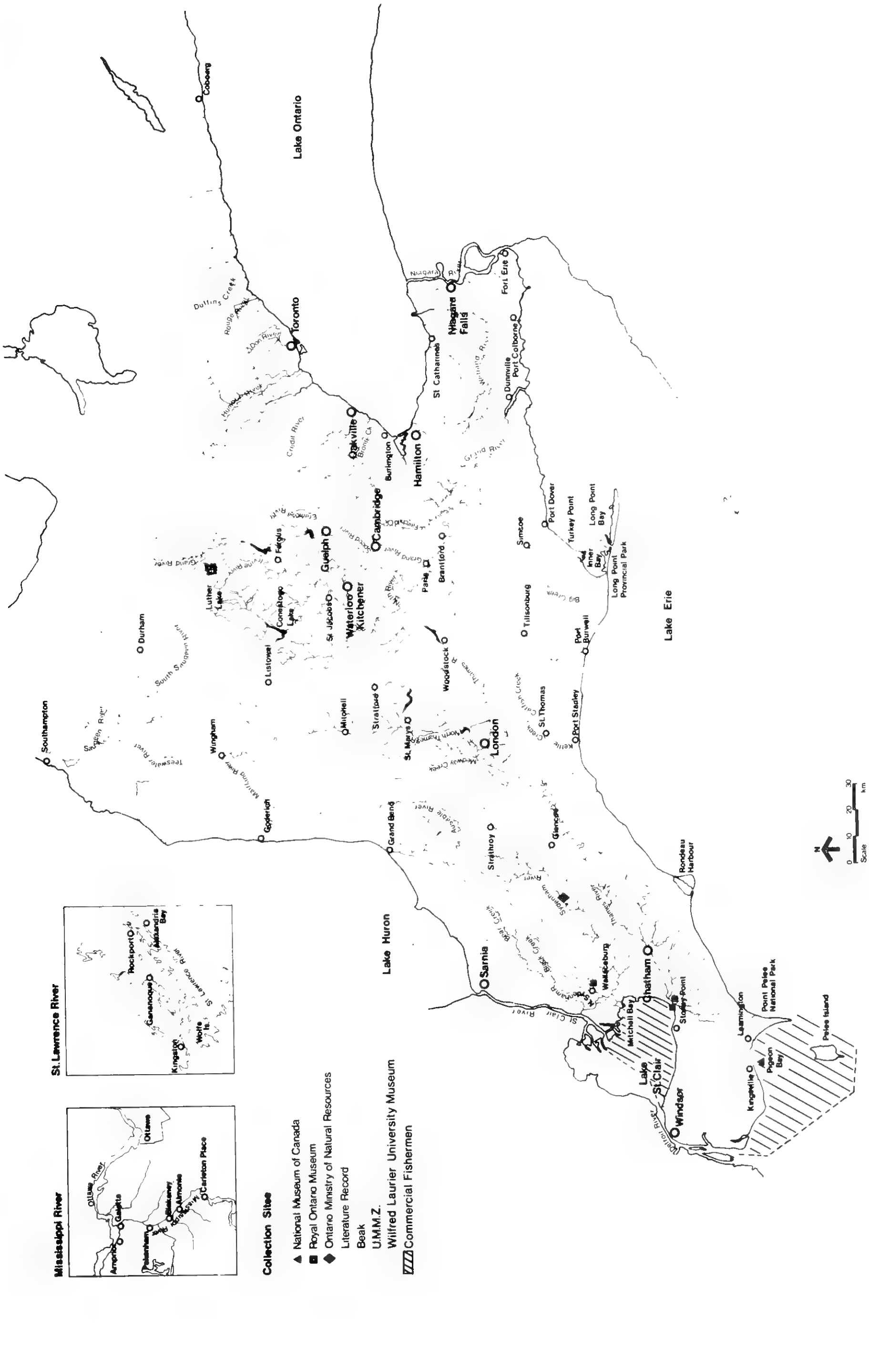

FIGURE 3. Collection records of the Spotted Sucker (*Minytrema melanops*) in Ontario.

gested that males and females may spawn more than once.

An estimated 38 000 eggs were contained within the one mature specimen captured in the Thames River. Spotted Sucker eggs hatch within 7 to 12 days after fertilization (Jackson 1957). Larval development was described by Hogue and Buchanan (1977) and White and Haag (1977).

Breeding males have two dark lateral bands separated by a pinkish band along the midside. Males are tuberculated on the snout, anal fin and both lobes of the caudal fin. Few tubercles appear around the eye and lower cheek region and on the ventral surface of the head.

The majority of Spotted Sucker specimens captured in Ontario waters have been adults. Both male and female specimens have been taken. The possibility of a small breeding population of Spotted Suckers existing in the Ontario waters of Lake Erie and Lake St. Clair is quite high; however, it will remain speculative until breeding records of young-of-the-year Spotted Suckers are obtained from Canadian waters.

The Thames River and Sydenham River may provide adequate spawning areas for the Spotted Sucker. The capture of this species in these rivers, and the presence of other catostomids which have similar spawning requirements to the Spotted Sucker suggest that suitable spawning areas exist in the Thames and Sydenham Rivers.

Data on the feeding habits of the Spotted Sucker in the Great Lakes are minimal. Specimens were not available for stomach content analysis during this study. Feeding habits of the Spotted Sucker in Kentucky have been described by White and Haag (1977). They found that the food preferences and feeding habits of the Spotted Sucker show distinct changes through the various life stages. Larval Spotted Sucker 12-15 mm (TL), began feeding in midwater and at the surface on zooplankton and diatoms while the yolk was still present in the gut. At 25 to 30 mm (TL) the Spotted Sucker ceased to feed at mid-depths and was observed feeding over patches of sand. Larvae up to 25 mm (TL) were observed feeding in shallow backwaters of creeks. At approximately 50 mm (TL) they began feeding on bottom benthic organisms, sand began appearing in the gut at this length. Specimens longer than 50 mm (TL) had feeding habits similar to adults. Adult Spotted Suckers feed individually, or in loose aggregations in quiet waters, over clean sand bars, during the day. By volume, the largest percentages of particles in the stomachs of adults were organic fragments and sand. Copepods, cladocerans, chironomids, and diatoms were identified as major food items. Molluscs have been mentioned by Miller and Robinson (1973), Harlan and Speaker (1956), and Pflieger (1975), as an important food item in the diet of Spotted Suckers. The protozoan *Myxosoma microthecum* was the only parasite Hoffman (1967) listed for this species. Hart and Fuller (1974) stated that an unidentified mussel had been listed as a parasite of the Spotted Sucker in Kentucky.

Young Spotted Suckers are probably preyed upon by several piscivorous fish and birds which are known from the same areas. This species is only incidentally captured in the Great Lakes basin, usually by hook and line or in trap nets. Jackson (1957) suggests that Spotted Suckers are captured for human consumption in the southern limits of its range. Those captured in commercial fishing in Ontario are lumped with other rough fish and sold as mullet or used for agricultural purposes.

Limiting Factors

There is insufficient information on Canadian populations to be able to define these factors, although the continued availability of suitable habitat is crucial to the survival of the species in what is the northern fringe of its distribution.

Special Significance of the Species

The Spotted Sucker has no commercial importance in Canada. Its continued well being, along with other species at the northern extremity of their ranges in Canada, will be an indication of good water quality and an absence of habitat degradation.

Evaluation

Given that: 1) a small reproducing population of Spotted Suckers probably exists in the western basin of Lake Erie, and in Lake St. Clair; 2) there is some indication that portions of this population may be using the Thames and Sydenham Rivers as spawning areas; 3) the Spotted Sucker is known in Canada at the northeastern fringe of its North American range; 4) a decrease in abundance of the Spotted Sucker in bordering waters since the 1920's is linked to increased siltation, and subsequent degradation of available habitat; and 5) there is insufficient information available to determine if this species is threatened by the actions of man which will cause its extirpation in Canada; it is recommended that the Spotted Sucker be classified as rare in Canada.

Acknowledgments

We would like to thank R. Haas of the Michigan Department of Natural Resources for his valued comments.

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Status of the River Redhorse, *Moxostoma carinatum*, in Canada*

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Parker, B., and P. McKee. 1984. Status of the River Redhorse, *Moxostoma carinatum*, in Canada. Canadian Field-Naturalist 98(1): 110–114.

The River Redhorse, *Moxostoma carinatum*, is rare in Canada, reproducing populations being known only from the Mississippi River in Ontario and the Richelieu and Yamaska Rivers in Québec. This species reaches its northeastern range limit in Canada and Canadian populations are distinct from those of the U.S.A. Populations are declining, possibly because of removal of adult specimens and habitat deterioration. The River Redhorse is not specifically protected in Canada, although general protection is afforded by the fish-habitat sections of the Fisheries Act.

Le suceur ballot, *Moxostoma carinatum*, est une espèce rare au Canada, dont les seules populations reproductrices connues se trouvent dans la rivière Mississippi en Ontario et les rivières Richelieu et Yamaska au Quebec. La limite nord-est de l'aire de répartition de cette espèce se trouve au Canada, et les populations canadiennes sont distinctes de celles des E.-U. Le déclin des populations est peut-être attributable au retrait de spécimens adultes et à la détérioration de l'habitat. Le suceur ballot ne fait l'objet d'aucune mesure de protection précise au Canada; il est toutefois couvert par certaines dispositions de protection générales prévues dans les articles de la Loi sur les pêcheries qui traitent de l'habitat du poisson. [Traduit par R. R. Campbell]

Key Words: Ontario, Québec, Mississippi River, Richelieu River, population size and trends, rare, distribution, redhorse sucker.

The River Redhorse (*Moxostoma carinatum*) is a moderately large sucker (Figure 1) usually 300-450 mm in length and up to 4 kg in weight (Scott and Crossman 1973). It is deep bodied and laterally compressed; a brown to lime-green colour dorsally, with pale sides and a white ventral surface. In Canada, it occurs in the St. Lawrence River watershed.

The species may be of limited economic importance due to its limited distribution and numbers. Younger fish may serve as forage fish.

Distribution

The River Redhorse is found in central and eastern North America. In Canada this species occurs in southern Ontario and southwestern Québec in the Great Lakes basin (Figures 2-3). However, the River Redhorse has often been misidentified and this may mask its actual distribution. The closest extant populations in the United States are believed to be in Kentucky and Missouri approximately 1300 kilometers southwest of the Canada populations, although isolated populations may exist in several localities in between.

Protection

International: Listed as endangered in Kansas (Platt 1974) and Ohio (Ohio Department of Natural Resources, 1976), threatened in Florida (Gilbert 1978), and rare in Missouri; it is believed to have been extirpated from Michigan, much of Iowa, Illinois, Indiana and Pennsylvania.

National: Not specifically protected in Canada, although fish habitat-sections of the Fisheries Act do afford general protection.

Population Size and Trend

Populations in Canadian waters are widely separated. Reproducing populations are known only from the Mississippi River in Lanark County, Ontario, and in southwestern Québec in the Richelieu and Yamaska River basins (Parker and McKee 1989; Mongeau et al. 1974). There are also records from the Ausable River in the drainage of Lake Huron, Fairchild Creek in the drainage of the Grand River and Lake Erie, and the St-Lawrence River basin in Québec in its tributaries from Lake St-Louis to the eastern outflow of Lake St-Pierre.

An estimate of the population size of River Redhorses in the Mississippi River was made by Parker and McKee (1980) who stated that this species comprises only about 5 per cent of redhorse species in this river. River Redhorse may be under significant stress from sportfishing. The Mississippi River at Pakenham and Blakeney is intensively fished during the summer months (approximately 250 man h/ha/year). A reduction in the number of redhorses caught in the Mississippi River at all sampling stations was observed between 1977 and 1979 surveys. Since River Redhorses are a large species they may be more frequently captured.

The presence of the River Redhorse in Fairchild Creek rests on a single collection of five immature

*Rare status approved and assigned by COSEWIC 6 April 1983.

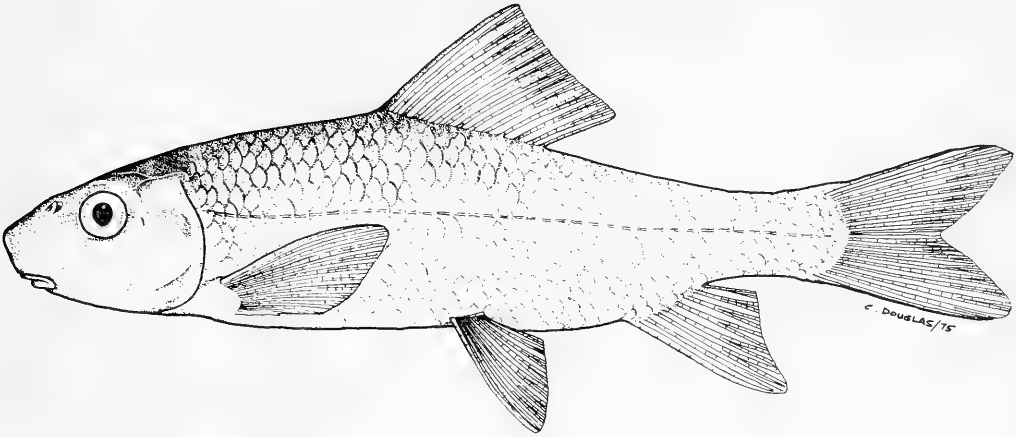

FIGURE 1. River Redhorse (*Moxostoma carinatum*). Courtesy of D. E. McAllister, National Museum of Natural Sciences.

specimens captured in 1971. Siltation and pollution may have degraded water quality to a level unsuitable for this species. A single collection of two adults in 1936 is the only indication of this species occurring in the Ausable River system.

Québec populations in the Yamaska and Richelieu Rivers are small. It was listed at all stations on the Richelieu River and abundant at only 2 out of 26 stations on the Yamaska River (Parker and McKee 1980). Jenkins (1970) stated that River Redhorse comprised only 5 per cent of all redhorse taken in the Yamaska River. Collections in other parts of southwestern Québec are few and population centres have not been identified.

Habitat

The River Redhorse has been captured in lakes and rivers within its Canadian range. This species prefers moderate to large rivers with gravel, rubble and bedrock bottoms where siltation is minimal (Trautman 1957; Jenkins 1970).

River Redhorse captured in the Mississippi River were taken from fast-flowing pools in a 300 meter-long chute and a catch-pool of a 1 to 2 meters high waterfall. Stream gradient was approximately 1.5 m/km over the entire river, but rapid changes in elevation are evident at both capture localities. Water flow volumes fluctuate in the Mississippi River from 14.6 cubic m/s in late summer to 142 cubic m/s during spring floods (Ontario Ministry of the Environment, 1977). The river bed in these areas is composed of limestone and granite bedrock, and rubble. A 1 to 2 cm layer of detritus covered the bottom in areas of slackened current.

This species was not observed in slow-moving stretches of the Mississippi River which had abundant macrophyte growth and soft substrates. Jenkins (1970) also noted that this species is rarely captured in deeper waters of slow flows which have silt and sand bottom. Aquatic vegetation at capture sites on the Mississippi River was restricted to encrusting and short filamentous algae, with patches of aquatic macrophytes growing in slack-water areas.

Turbidity was quite low at capture sites (Secchi disc transparency approximately 1 meter). Jenkins (1970) stated that the River Redhorse is intolerant of turbid waters, and increased turbidity and siltation are usually followed by a decrease in population numbers. Trautman (1957) also reported reduction in population numbers for this species in heavily silted and polluted rivers and streams in Ohio. In the Mississippi River water temperatures reach 25° C during the summer, and dissolved oxygen levels as low as 3 mg/L have been recorded (Ontario Ministry of the Environment 1977). However, dissolved oxygen levels usually average 7 to 10 mg/L during summer months when water temperatures are highest (Parker and McKee 1980).

General Biology

The best general account of the biology of the River Redhorse in Canada is summarized in Parker and McKee (1980). The maximum total length was a fish 617 mm long, weighing approximately 2814 gms. Another specimen was aged as being 14 years. Growth rate for mature Ontario River Redhorse was approximately 40 per cent slower than that calculated by Purkett (1958) for Missouri fish. Age at maturity is

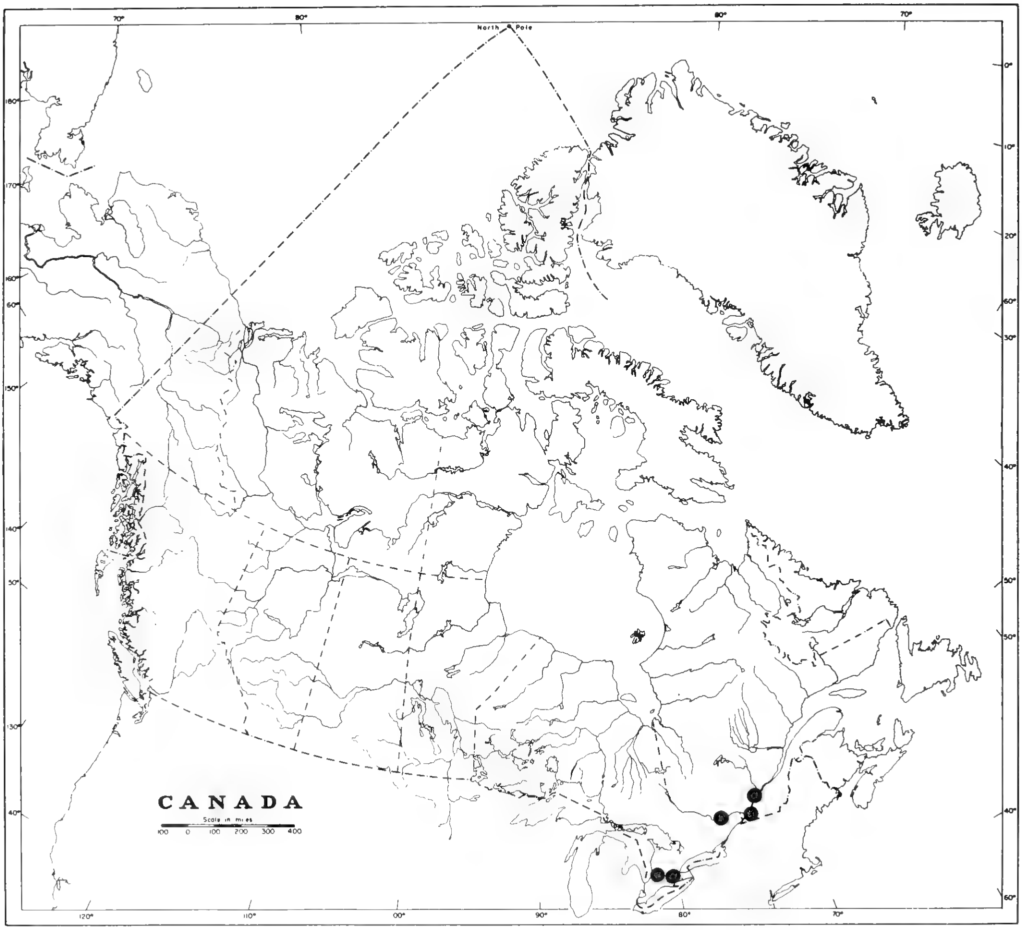

FIGURE 2. Canadian Distribution of the River Redhorse (*Moxostoma carinatum*). Courtesy of D. E. McAllister, National Museum of Natural Sciences.

not known and males and females are not known to differ in growth rate. Spawning has not been observed in Canadian waters but occurs in large rivers or upper reaches of some large tributaries in the USA. The timing of spawning is at water temperatures of 22-24° C which are found in the Mississippi River of Ontario in late May or early June. Tuberculate males have been captured in early June in Québec, but by early July specimens had tuberculate scars (Jenkins 1970). In the USA, spawning occurs over gravel shoals in waters from 0.15 to 1 meter deep. Males constructed redds varying in size from 1.2 to 2.4 meters in diameter and from 20 to 30 centimeters deep. Males are territorial, but spawning required 2 males and 1 female, The second male would join the first in the redd just prior to spawning and leave during the spawning act, or immediately thereafter. Males tended to spawn with females larger than themselves. Egg numbers were 6078-23085 for fish 45 to 65 cm in total length and were relatively large (3-4 mm diameter). They hatched in the gravel in approximately six days at 24° C.

River Redhorse feed extensively on benthic organisms by sight and are, therefore, susceptible to an introduced bait either on the bottom or in midwater. Gut contents of 10 Ontario specimens showed that

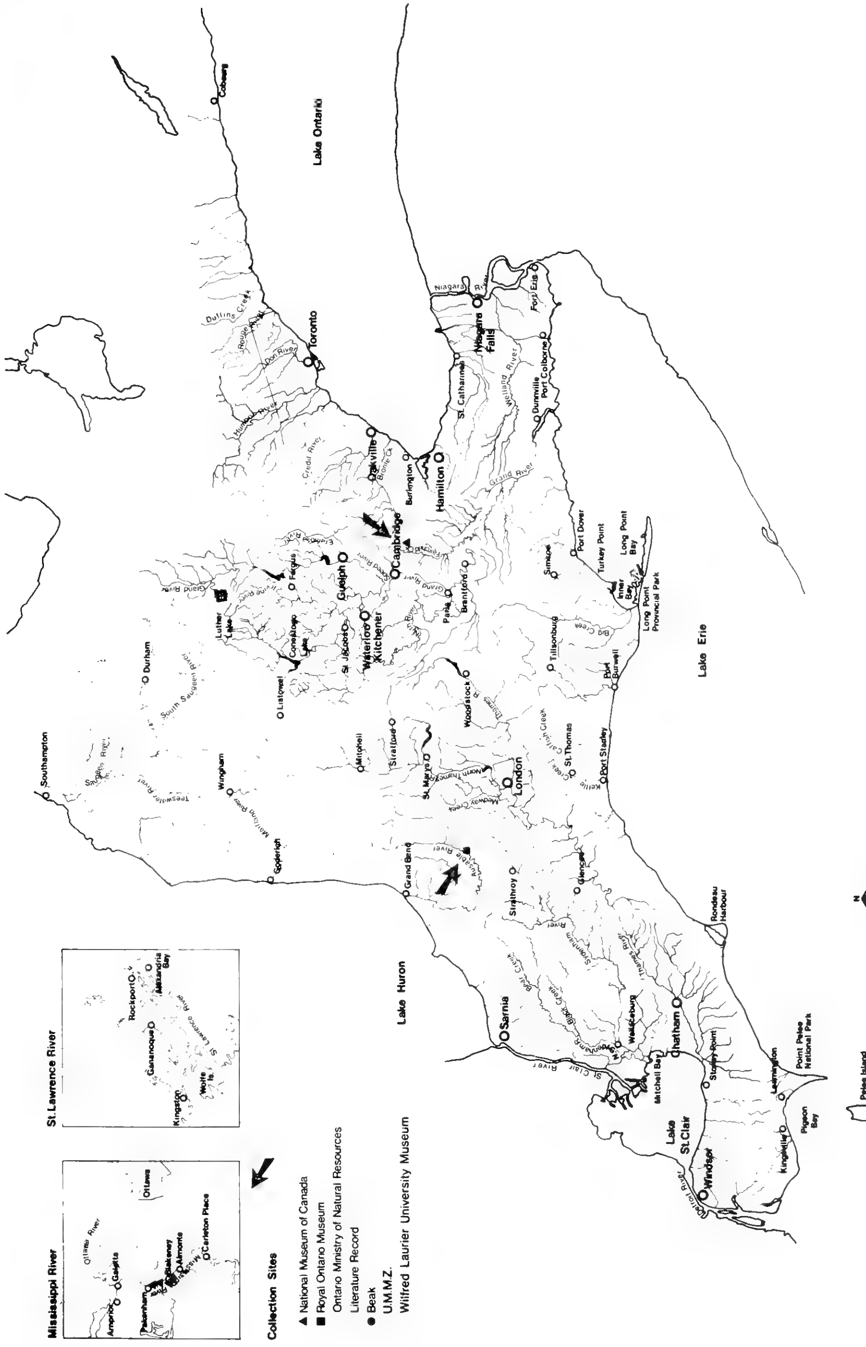

FIGURE 3. Collection records of River Redhorse (*Moxostoma carinatum*) in Ontario.

fish 100-150 mm long fed primarily on chironomid larvae and pupae, while fish 200-250 mm long also ate crustaceans, trichopterans and coleopterans. Larger River Redhorse feed on molluscs, insect larvae and crayfish.

The large adult size of River Redhorse and rapid growth rate of young-of-the-year exclude this species from the diet of many predators.

Limiting Factors

This species is classed as a coarse fish by the Ontario Ministry of Natural Resources and is not protected by catch limits, minimum size restriction, or spear fishing regulations. Given its bait-taking propensity, sport fishing may affect population numbers. River Redhorse are intolerant of turbid waters and in the Mississippi River low dissolved oxygen levels (3 mg/L) have been reported which may also be a limiting factor. It is also a commercial species of some importance in some areas (Scott and Crossman 1973), but not usually separated from other redhorses in the catch (all suckers are marketed as mullet). Large unregulated commercial catches could also cause serious depletions of local populations.

Special Significance of the Species

Canadian populations are at the northern limit of the range of this species and are distinct from surviving populations in the USA. It has some importance to sport and commercial fishermen. As one of the few mollusc-eating fishes in Ontario, the River Redhorse plays an important role in the aquatic ecosystem.

Evaluation

The following statements were considered valid, after review of the available information, and were used in the evaluation of the status of the River Redhorse in Canada:

1. Reproducing populations are known only from the Mississippi River in Ontario and from the Richelieu and Yamaska Rivers in Québec.
2. All known populations in Canada are small in number, restricted in distribution and at the northeastern limit of the species range in North America. They are distinct from populations in the USA.
3. Watercourses in southern Ontario in which this species has been recorded may no longer be suitable for this species as a result of man's actions.
4. The only known surviving population of this species in Ontario is decreasing in number due to the actions of man, possibly by removal of adult specimens and habitat deterioration.

Based on the information evaluated it is recommended that the River Redhorse be classified as rare in Canada.

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Status of the Giant (Mayer Lake) Stickleback, *Gasterosteus* sp., on the Queen Charlotte Islands, British Columbia*

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Moodie, G. Eric E. 1984. Status of the Giant (Mayer Lake) Stickleback, *Gasterosteus* sp., on the Queen Charlotte Islands, British Columbia. Canadian Field-Naturalist 98(1): 115–119

The Mayer Lake population of Giant Stickleback appears to be stable. Population estimates have never been conducted, however, so it will be difficult to detect future population trends. The population does not appear to be under any immediate threat, but this may change if densities of Cutthroat Trout decline due to the increasing angling pressure. Trout densities should, therefore, be monitored as this predator is important in maintaining the phenotype of the Giant Stickleback and in excluding the common form of *Gasterosteus aculeatus* from the habitat of the Giant Stickleback.

La population d'épinoches géantes semble être stable. Toutefois, comme elle n'a jamais été estimée, il est difficile de suivre son évolution. A l'heure actuelle, elle n'est pas menacée, mais la situation pourrait changer si la densité des truites fardées diminue par suite de la pêche sportive intensive. Un programme de surveillance des truites devrait être mis en oeuvre car ce prédateur représente un facteur important du maintien du phénotype de l'épinoche géante et de la disparition de l'épinoche à trois épines dans l'habitat de l'épinoche géante.

Key Words: British Columbia, Queen Charlotte Islands, Mayer Lake Stickleback, rare, distribution, population size and trends.

Threespine Sticklebacks (*Gasterosteus aculateus*) are small, (average length 3.1 cm), laterally compressed fishes with slender caudal peduncles, with a nearly circumpolar distribution in fresh and salt waters. These fish are characterized by a dorsal fin consisting of three isolated, stout, serrated spines, the last being relatively short (Scott and Crossman 1973). In Canada, the Threespine Stickleback is common along the Hudson Bay coast and east to Newfoundland and the Atlantic provinces. In British Columbia, they are prevalent along the coast, north to the Bering Strait and occur on most offshore islands such as the Queen Charlotte Islands.

On the Queen Charlotte Islands the Threespine Stickleback displays extensive morphological variation between populations (Moodie 1972 a, b; Moodie and Riemchen 1973, 1976 a) and several of these have diverged markedly from others. Some of these are unique enough to be considered separate species. Some ecologists argue that the Queen Charlotte Islands were covered by ice during the last glaciation and others argue that the Queen Charlotte Islands remained ice-free (McAllister et al. 1981). Did populations of the Threespine Stickleback on the Queen Charlotte Islands evolve rapidly after the glaciers receeded leaving numerous unconnected inland lakes? Further study is required before such questions can be answered. At any rate, we have studies on over 120 such populations in as many lakes and four endemic populations have been found which have diverged markedly enough to meet all the criteria of a biologically defined species (Moodie and Reimchen 1973, 1976 a, b; Bell 1977). The present report, documents the status of one such population which is known to exist only in Mayer Lake, British Columbia.

In Mayer Lake in the Queen Charlotte Islands of British Columbia, is a large, black, long-spined relative of the Threespined Stickleback to which we have given the name Giant Stickleback (*Gasterosteus* sp.). These fish (Figure 1) may be more than twice as large (up to 8.4 cm as compared to 3.1 cm) as the Threespined Stickleback, which are found in the same lake and tributary streams. The two forms differ in size, in colour and in six meristic and morphometric characteristics, as well as in behaviour and habitat. Presumed hybrids are occasionally found. Giant Sticklebacks have also been described from North Vancouver Island and near Prince Rupert but at this time it is not known if these are related. Similarity between these populations is probably due to convergence (Moodie and Reimchen 1976 a,b,).

Distribution

The Giant Stickleback is found only in Mayer Lake (53°40′, 132°02′W) on the eastern side of Graham Island, the largest of the Queen Charlotte Islands, in British Columbia (Figures 2 and 3).

Protection

Mayer Lake and much of its drainage basin is

*Rare status approved and assigned by COSEWIC 6 April 1980.

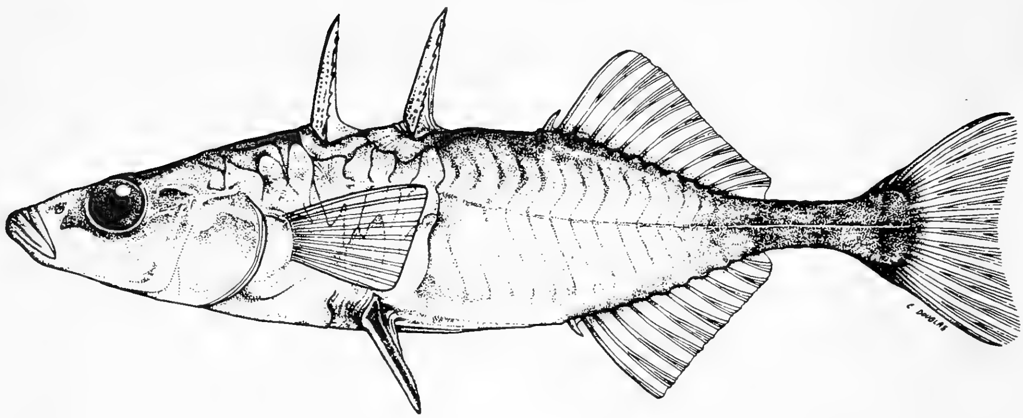

FIGURE 1. The Giant Stickleback (*Gasterosteus* sp.) S.L. = 8.4 cm. Courtesy of D. E. McAllister, National Museum of Natural Sciences.

within the boundary of a Provincial Park (Naikoon Park). The Lake is thus now protected from the real-estate development and small scale (pole) logging which occured in the past. Park status does not, however, restrict recreational activities such as fishing and boating. A 1971 (Peden 1971) recommendation that the lake and watershed be declared an Ecological Reserve to protect the Giant Stickleback and associated species has recently been approved by the Provincial Government.

Population Size and Trend

No population estimates have ever been made. The fish are patchily distributed in the lake with different age classes and sexes occuring in different areas during different seasons. Given the above circumstances, an estimate of actual numbers will be no more than a wild guess — my tentative prediction is that the population numbers a few hundred thousand. This fish has always been easy to seine in large numbers and their density does not appear to have changed since my first collections in 1966. The limited information suggests a stable population, however, the real population trend is unknown.

Habitat

The Giant Stickleback has a localized distribution, as it occurs only in Mayer Lake. Mayer Lake is 12.1 km long and averages 0.8 km in width; its surface area is about 627 hectares. The maximum depth is about 9 m. The Giant Stickleback does not appear to enter either the three inlets or the outlet stream connected to the lake.

Until recently, the rate of habitat change has been slow, but this may change in the near future. Improvements in transportation to the Queen Charlotte Islands are resulting in increased tourism. Both tourists and residents are putting more and more fishing pressure on Cutthroat Trout (*Salmo clarki*) in Mayer Lake. The Giant Stickleback is a fish whose phenotype has resulted from selection by predators such as Cutthroat Trout and Common Loons (*Gavia immer*). Should trout densities decline and loons leave the lake due to disturbance by boaters, one would predict that the Giant Stickleback would be replaced by the typical form of stickleback which is found in the inlet streams of Mayer Lake.

Although the habitat is protected to some extent in that the Mayer Lake drainage basin is entirely on Crown land and largely within Naikoon Provincial Park, the biotic integrity of the community may be inadequately protected as a result of developing angling trends. It is doubtful whether one can confidently predict if trout densities will be maintained under current angling regulations and enforcement practices. Depletion of trout stocks, introduction of non-native game fish, and introduction of bait fish are all known possible consequences of over-fishing which would singly or collectively have a deleterious effect on the Giant Stickleback. The presence of many mature (i.e. large) Cutthroat Trout as well as Common Loons may be as important in the long term for the well-being of this population as an oligotrophic lake containing sand and gravel beaches for spawning is in the short term.

General Biology

The Giant Stickleback first reproduces in its third

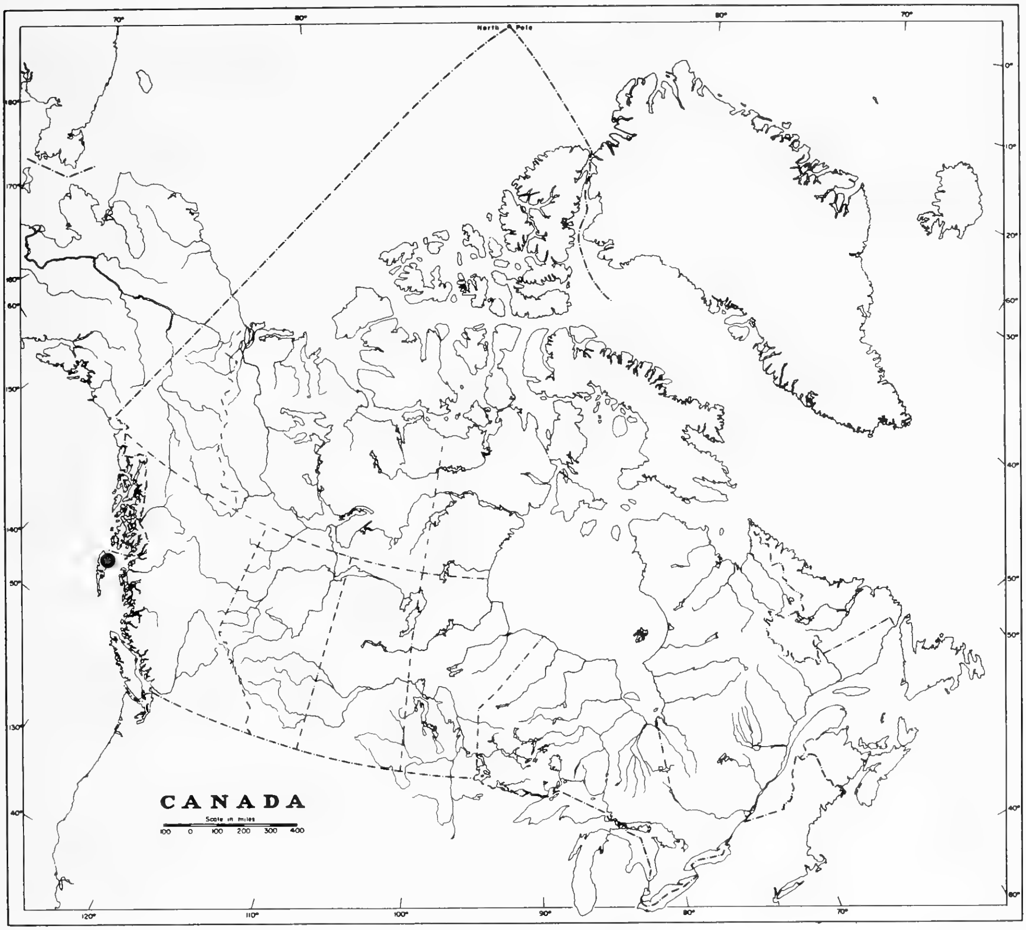

FIGURE 2. Distribution of the Giant Stickleback. Courtesy of D. E. McAllister, National Museum of Natural Sciences.

summer. During the breeding season males probably complete about five nesting cycles and then die. The number of clutches produced by females is not known, but they too, probably reproduce only during their third summer and then die. Females produce an average of 257 eggs per clutch. The Giant Stickleback, like other members of the genus, is territorial. Nesting males are found in clumps where the substrate is sand or gravel and there is some shelter such as *Fontinalis* or rocks. The reproductive rate in Mayer Lake appears to be normal.

Movement of the Giant Stickleback is limited, it appears to spend its entire life within the lake. During a three-month period from May to August, males concentrate in localities where there is a sand substrate, a gentle gradient, and vegetation. These spawning areas are unprotected, but are widespread.

The Giant Stickleback feeds in the limnetic zone on zooplankton. It is tolerant of human disturbance and responds readily to change. Unfortunately, it is its ability to respond to change that makes change undesirable. Response to change could lead to adaptive alterations of the phenotype and hybridization with the typical sticklebacks of the streams, in which case the unique nature of the Giant Stickleback would be lost even though population densities might not change. This stickleback is susceptible to fluctuations in water level through its dependence on shallow

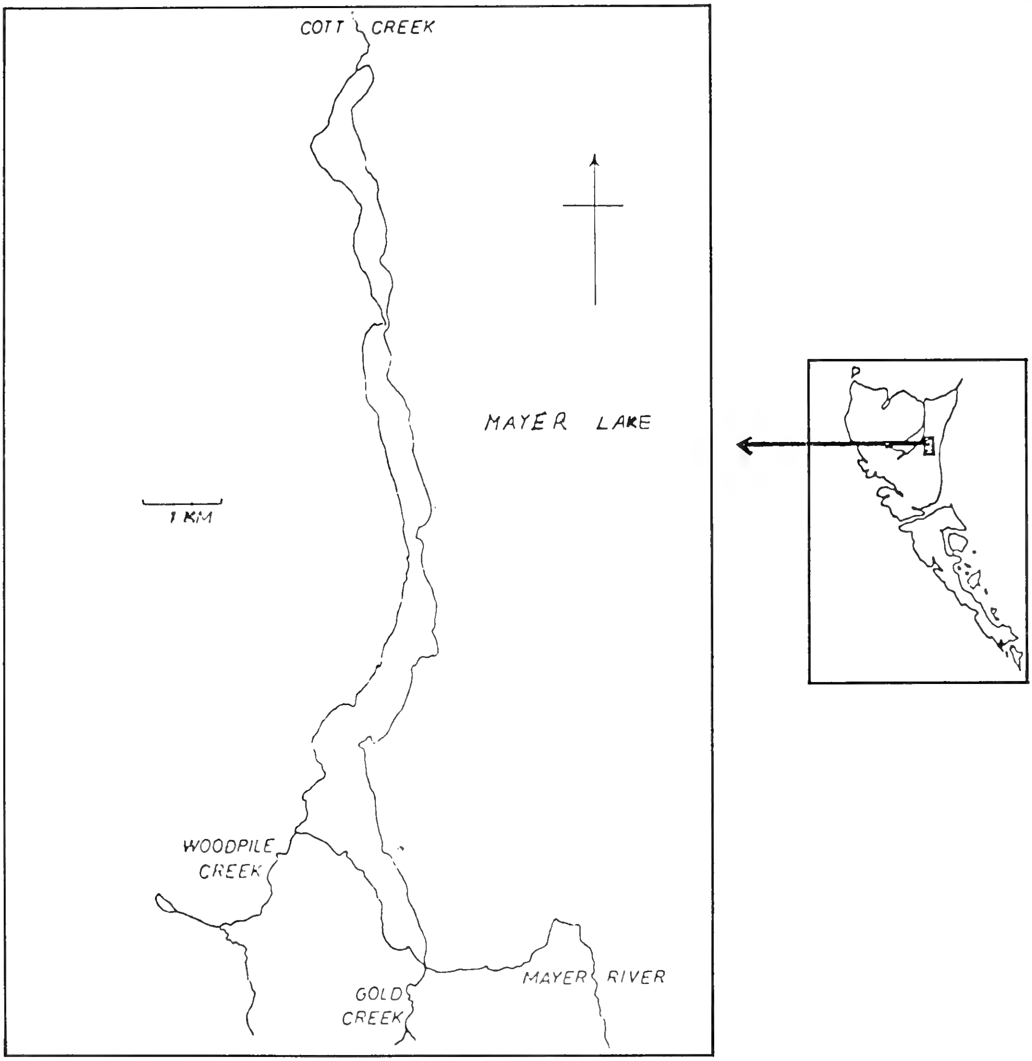

FIGURE 3. Range map for the Giant Stickleback which is found only in Mayer Lake, Queen Charlotte Islands.

beaches during the spawning season. High water forces the fish to nest at depths where the exposure to trout is increased. Drops in water level during the breeding season can expose eggs to excessively high temperatures and cause the male to abandon the nest. Fluctuations in water level are becoming more common in the Queen Charlotte Islands as the Beaver (*Castor canadensis*), introduced after World War II, expands its range.

Limiting Factors

The population appears to be stable. Numbers may be regulated by the availability of spawning sites and by predation. Fluctuating water levels resulting from

Beaver activity will probably influence the availability of spawning sites. Unfortunately, there appears to be no way of controlling Beaver densities. The number of predators, however, can be managed.

Special Significance of the Species

The Giant Stickleback was the first, and remains one of only two, of a number of unique Canadian stickleback populations to be studied and described. It differs from other morphologically similar species in that it is parapatric with the typical form of *Gasterosteus aculeatus.* Other similar populations exist, but are probably genetically unrelated and the result of convergence.

The taxonomic status of the Giant Stickleback has not been decided; in many respects the population fulfills the requirements of the biological species definition. Most of those working on *Gasterosteus* in the Pacific Northwest feel, nevertheless, that to describe new species at a time when research is continuing, and new findings constantly emerging, would be unwise.

Although the Giant Stickleback of Mayer Lake has been singled out for attention, this is largely the consequence of its being the first unusual stickleback on the Canadian west coast to be studied and publicized. Actually there are a number of equally significant forms of *Gasterosteus* in the Queen Charlotte Islands which may be more easily endangered than the one in Mayer Lake. Sticklebacks in Boulton Lake for example, are unexposed to predation of fish and so have lost many of the defensive spines characteristic of the genus. Game fish could easily be introduced to this lake with results that would probably be disastrous for its extremely differentiated sticklebacks.

Evaluation

No population decline is apparent and as long as the trout population does not decline, or steps are taken to prevent overfishing of trout, the Giant Stickleback population should survive. At present, considering its limitation to one population in one lake, the species should be considered rare.

Acknowledgments

Dr. T.E. Reimchen, a resident of the Queen Charlotte Islands for the past six years and active in stickleback research there, provided current information on all aspects of this report. During his years on the islands, Tom Reimchen has served as an advocate for the sticklebacks and environmental protection in general. He deserves much of the credit for the level of environmental awareness that exists in the Queen Charlotte Islands.

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Status of Unarmoured and Spine-deficient Populations (Charlotte Unarmoured Stickleback) of Threespine Stickleback, *Gasterosteus* sp., on the Queen Charlotte Islands, British Columbia*

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Reimchen, T. E. 1984. Status of unarmoured and spine-deficient populations (Charlotte Unarmoured Stickleback) of Threespine Stickleback, *Gasterosteus* sp., on the Queen Charlotte Islands, British Columbia. Canadian Field-Naturalist 98(1): 120–126.

Endemic populations of the Threespine Stickleback (*Gasterosteus aculeatus*) with major loss of spines and lateral plates and tolerance to naturally acidic waters occur in three small lakes in the Sphagnum dominated lowlands of the Queen Charlotte Islands, British Columbia. Recent range extension of the Beaver (*Castor canadensis*), an introduced species on the islands, has resulted in increased water levels and organic debris in two of the lakes. Population numbers of stickleback appear to be stable, although the increase in organics may influence the reproduction of the fish. Introduction of Cutthroat Trout, *Salmo clarki*, a predator on stickleback, could seriously decrease numbers in these small populations, or, more likely, significantly modify their genetic structure. These populations can be categorized as "rare".

Des populations endémiques d'épinoches à trois épines (*Gasterosteus aculeatus*), qui ont perdu la majorité de leurs épines et de leurs plaques latérales et qui tolèrent l'acidité naturelle des eaux, peuplent trois petits lacs des basses terres des Iles Reine-Charlotte (Colombie-Britannique) où pose surtout la sphaigne. La montée des niveaux d'eau et l'accumulation de débris organiques dans deux de ces lacs sont le résultat des activités du castor (*Castor canadensis*), une espèce nouvellement venue dans les Iles, dont la répartition s'est étendue récemment. Le nombre d'épinoches semble être stable, quoique l'accumulation de débris organiques puisse influer sur la reproduction de ce poisson. L'introduction de *Salmo clarki*, un prédateur de l'épinoche, pourrait entrainer une diminution importante de ces populations déjà peu nombreuses, mais plus probablement modifier leur structure génétique de façon importante. Ces populations entrent dans la catégorie "rare". [Traduit par R. R. Campbell].

Key Words: British Columbia, Queen Charlotte Islands, Boulton Lake, Rouge Lake, Serendipity Lake, sticklebacks, rare, distribution.

On the Queen Charlotte Islands, British Columbia, the Threespine Stickleback (*Gasterosteus aculeatus*) displays extensive morphological variation between populations (Moodie and Reimchen 1973, 1976; Moodie 1984). Since 1976, some 120 lakes from remote localities on the islands have been sampled in order to provide a description of the species variability throughout the archipelago. The present report describes three endemic populations which diverge markedly from other populations.

The common freshwater form of the stickleback normally has three dorsal spines, an anal spine, two pelvic spines and a series of lateral bony plates. These characters are of prime importance in defense against vertebrate predators (piscivorous fish and birds). The three populations discussed here are exceptional in that they show major reduction, or loss, in these characters, as well as reduction in numbers of fin-rays and in other bony elements (Figure 1). There are reasonable grounds for assuming that lateral plate and spine differences are genetic traits, while fin-ray variation is influenced both by temperature and inheritance (Lindsey 1962).

Distribution

The three lakes (Boulton, Rouge and Serendipity) are located in the Queen Charlotte lowlands, an expanse of bog and coniferous forest that dominates the northeast corner of Graham Island (Figures 2 and 3). Other than those on the Queen Charlotte Island, Threespine Stickleback with comparable morphologies have been reported from one lake on Texada Island, British Columbia (J. D. McPhail, personal communication) and several lakes in California (Miller 1960) and the Outer Hebrides in Scotland (Campbell 1979).

Protection

Threespine Stickleback have no formal protection; they are common and widely distributed in a diversity of habitats. However, some populations with divergent fish have been given protected status, including the large, Black Stickleback from Mayer Lake (Moodie 1984), Queen Charlotte Islands (an Ecological Reserve), and the plateless *G. aculeatus williamsoni* in California.

*Rare status approved and assigned by COSEWIC 6 April 1983.

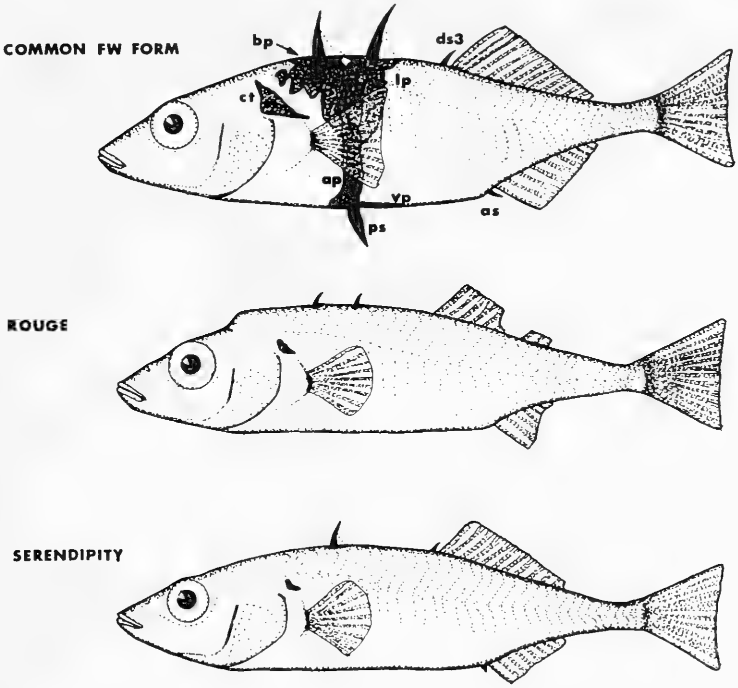

FIGURE 1. Representative specimens of *Gasterosteus aculeatus*. Boulton Lake stickleback (not shown) similar to those from Serendipity Lake. ap = ascending branch of pelvic skeleton, as = anal spine, bp = basal plate of dorsal spine, ct = cleithrum, ds3 = third dorsal spine, lp = lateral plates, ps = pelvic spine, vp = ventral plate of pelvic skeleton. Magnification X2.

Population Size and Trends

Total numbers of fish in each lake have not been determined; however, it was possible to obtain crude estimates of density by using a range of sampling techniques. Such estimates give a total population of 350 000 for Boulton Lake; 17 500 for Rouge Lake; and 22 000 for Serendipity Lake. As assessed from trap success (numbers of fish per trap hour), there had been no obvious changes in the abundance of fish during the sampling period (Boulton: 1970-1981; Rouge: 1976, 1978, 1980, 1981; Serendipity: 1979-1981). The expansion of the Beaver (*Castor canadensis*), as discussed below, may have an adverse effect on population numbers in the future.

Habitat

The broad characteristics of the three small lakes are summarized in Table 1. The watersheds are not connected and have separate drainages to marine waters. Each lake is surrounded by Sphagnum bog and scrub coniferous forest; these watersheds are similar to adjacent areas where lakes with "normal" stickleback are found. In the last 20 years, the natural drainage system in the area has changed due to the activities of the Beaver.

Beaver were introduced onto the Queen Charlotte Islands by the British Columbia Game Commission in 1949. Since that time, they have extended their range throughout much of Graham Island. In the lowland region, the alteration of habitat has been extensive. Water levels have risen, resulting in submergence of large areas of Sphagnum bog and inundation of cedar forest. Previously isolated lakes have been connected and small creeks where Coho Salmon (*Oncorhynchus kisutch*) are found have been blocked. It is primarily the small lakes and ponds (≤ 20 ha) which have been adversely affected. Aerial photographs from 1937 to the present show a loss of the sandy littoral areas in several lakes since the mid-1950's and a general increase in the surface area of others.

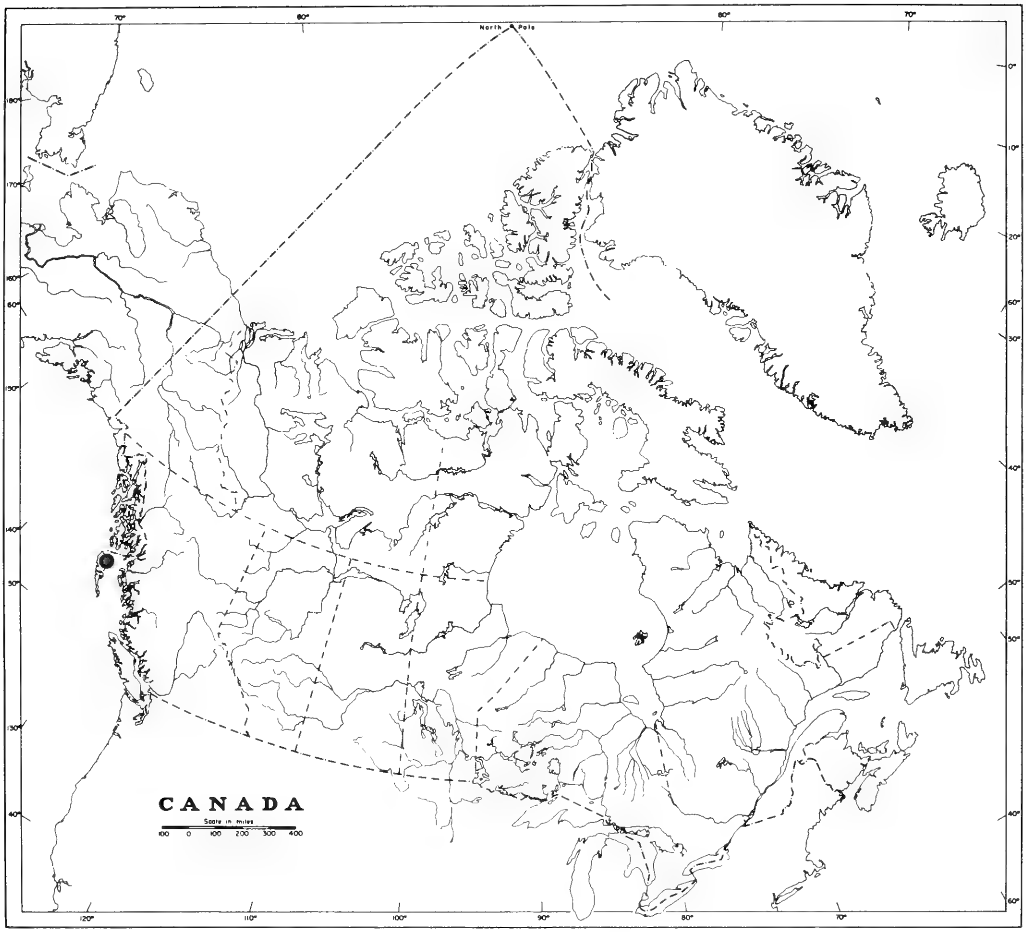

FIGURE 2. Distribution of Unarmoured Stickleback (*Gasterosteus* sp.) in Canada. Courtesy of D. E. McAllister National Museum of Natural Sciences.

Habitat Trends

Boulton Lake. There have been no significant changes in water levels or in the lake basin between 1970 (when the lake was first visited) and 1981.

Rouge Lake. In 1970, when this lake was first sampled, the shoreline was characterized by broad sand beaches which extended to the edge of vertical Sphagnum banks. Breeding stickleback were observed throughout this shallow area. Between 1970 and 1975, Beaver gained access to the watershed and blocked the outlet stream. This resulted in a 0.5 to 1 m increase in the lake level, with a subsequent elimination of the shallows. Dead Sphagnum from the banks and Lodgepole Pine (*Pinus contorta*) have fallen into the lake. The sand substrate, although still present in some microhabitats, is now largely covered with a layer of these organics. Furthermore, since the water is extensively stained (from humic acids), only a small amount of light penetrates to the bottom of the lake and higher water levels have decreased the photic zone near the shore. Some of these factors have already led to an irreversible change in the fish population. In 1970, breeding male sticklebacks had very well-developed red throat pigmentation, yet this has not been observed in any fish collected from 1978 to the present. Dolly Varden (*Salvelinus malma*) were com-

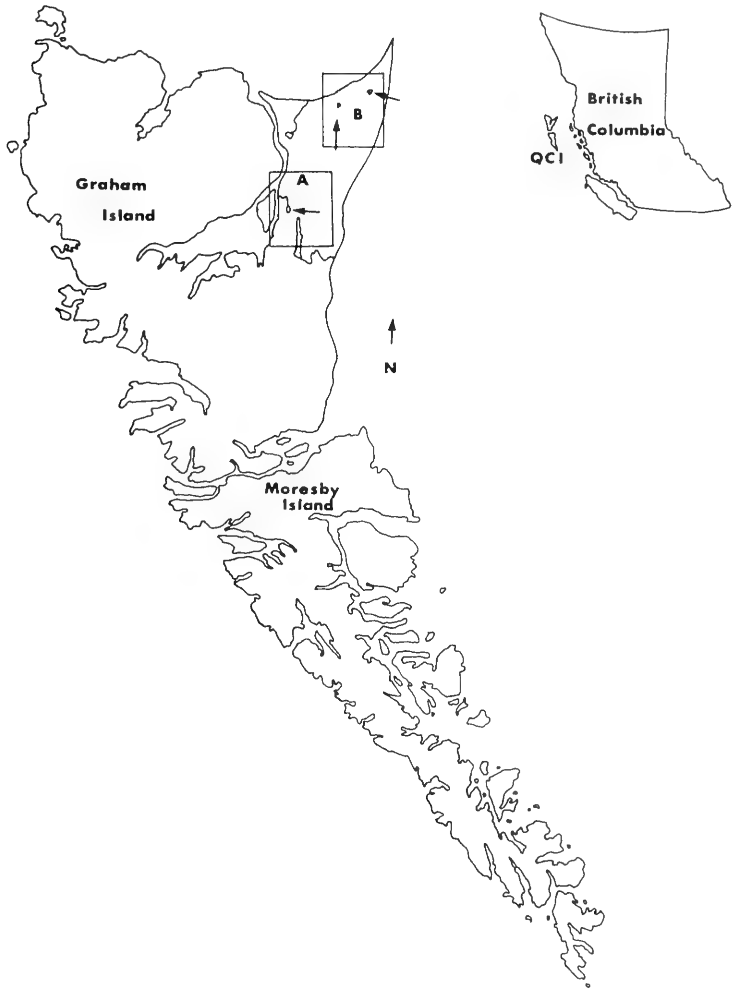

FIGURE 3. Range maps of Unarmoured Stickleback (*Gasterosteus* sp.) on the Queen Charlotte Islands. Block A shows Boulton Lake, Block B shows Rouge and Serendipity Lakes.

mon in the lake in 1976 and 1978, but were not observed during two visits in 1981. This may be a sampling artifact and will require confirmation. Rouge Lake, while going through a period of rapid change in the 1970's, appears now to have a stabilized water level.

Serendipity Lake. The habitat changes in this lake are similar to those of Rouge Lake, except that Beaver were first observed in 1979; by 1981, there had been a 0.5 m increased in the lake level and a 30 per cent increase in the surface area. Most of the former Sphagnum banks are submerged and a 2 ha conifer stand near the former outlet is inundated. There has been a fall in pH from the mid 4's in 1979 to 3.90 in 1981, a possible result of flooding of the Sphagnum bog.

Protection of habitat

Boulton Lake. The lake and watershed lie on crown land within walking distance of the single Island highway. Although there is some local awareness that the lake contains unusual fish, this is offset by growing pressure for recreational areas, which may include

TABLE 1. Habitat description of Boulton, Rouge and Serendipity Lake, Queen Charlotte Islands, British Columbia

Parameter	Boulton	Rouge	Serendipity
Size (ha)	18	1.7	2.2
Maximum depth (m)	4.2	2 (estimated)	2 (estimated)
pH	4.7	4.1–4.5	3.9–4.3
Water colour	clear	stained	stained
Substrate	sand, gravel, organic ooze	sand, organic ooze	organic ooze
Water source		*Sphagnum* see page 121	
Outlet	intermittent	closed (beaver dam)	closed (beaver dam)
Nuphar luteum cover (%)	10	50	50
Surrounding vegetation	*Sphagnum* *Pinus* *Thuja*	*Sphagnum* *Pinus*	*Sphagnum* *Thuja* *Chamaecyparis*
Fish species	*Gasterosteus*	*Gasterosteus* *Salvelinus malma*	*Gasterosteus*

introduction of trout for the sports fishery. As well, proximity to the road makes the lake sensitive to future rural and industrial activities. During the last three years, logging operations have increased in adjacent watersheds.

Rouge Lake. This lake is located on a 130 ha private holding within Naikoon Provincial Park. One of the land owners intends to develop his holding for small-scale agricultural use if, and when, road access rights through the Park are approved. Presently, Parks' authorities have not granted a permit for such road access and the lake remains undisturbed (apart from Beaver activity).

Serendipity Lake. This watershed is within Naikoon Provincial Park and thus rural and industrial development are excluded.

Degree of specialization

Rouge and Serendipity Lakes are in an advanced stage of bog succession with overhanging banks of Sphagnum and major cover by *Nuphar luteum*. The extreme reduction of defensive traits is probably intimately related to this successional stage, since fish predators and large avian piscivores are excluded from the system, either by the acidic conditions or the small size of the lakes. Increased surface area of Rouge and Serendipity Lakes, due to beaver activity, will result in a greater utilization of the lakes by predatory birds such as loons (*Gavia immer* and *G. stellata*) which are abundant in this region (Reimchen and Douglas 1980).

General Biology

The sticklebacks in these lakes have a breeding structure similar to other populations of sticklebacks. Sex ratio is close to equality, females produce from 100-300 eggs, and breeding occurs in the third year, after which post-reproductive individuals die. In each lake, large numbers of fry have been observed. While numbers of fish appear to be similar each year, I suspect that, at Rouge and Serendipity Lakes, the increased organics on the lake bottom and reduced light transmission onto the nesting areas could adversely affect nest construction and reproductive success. Anaerobic conditions prevail very close to the surface layer of organic debris in bog pools (Moore and Bellamy 1974) and could suppress egg development in nesting stickleback.

The sticklebacks spend their entire life within the lake. Fry and adult males are found primarily near shore in spring and summer and move into deeper water during winter months. Females and sub-adults occur in open water near the surface during summer and in benthic regions in winter.

Limiting Factors

There are several factors which could influence the present populations:

1. Introduction of Cutthroat Trout (*Salmo clarki*). These populations of endemic stickleback occur only where predatory fish are absent. Cutthroat Trout are the major fish predator on the stickleback and are widely distributed on the Queen Charlotte Islands. Dolly Varden, which are also widely distributed, forage on benthic invertebrates and do not normally feed on stickleback in this region. Artificial introduction of Cutthroat Trout into any of the three lakes would seriously reduce numbers or change the genome, since fish lacking defensive traits would be selectively eliminated from the population.

2. Winter kill. This is a potential problem for all fish populations during severe winters, especially

TABLE 2. Percentage of fish with missing spines and lateral plates

	% of Fish Missing Spines and/or Lateral Plates					
Lake	1st Dorsal	2nd Dorsal	3rd Dorsal	Pelvic	Anal	Lateral Plates
Boulton	0.03	80.0	2.3	65	6	0
Rouge	31.0	0.7	63.0	0	86	50
Serendipity	5.8	0	0	97	0	100

those in small lakes and ponds. Each of the three lakes had complete ice cover during the last three winters, and in Boulton Lake, where measurements were taken, ice thickness reached 45 cm and remained on the lake for nine weeks. That these small populations have not been winter killed for at least several thousand years may relate to the unusual limnological conditions to which the fish are exposed. One of the characteristics of Sphagnum is its capacity to bind cations. This results in highly acidic run-off, which among other factors, inhibits bacterial decomposers. Since oxygen depletion from bacterial activity is an important cause of winter kill, the naturally acidic conditions in these lakes may have contributed to winter survival of the fish. I have not yet found stickleback populations resident in any small ponds where pH values are near 7. European workers have shown that oxygen depletion in bog pools is significantly increased at higher pH values (Moore and Bellamy 1974). Domestic cattle or agricultural activity at Boulton or Rouge Lakes could result in higher pH. Lake fertilization programs, currently being conducted on the Queen Charlotte Islands by Federal Department of Fisheries and Oceans, could be expected to have a similar effect if any of these three lakes were artificially "enhanced".

Special Significance

These populations of stickleback are characterized by loss of morphological structures associated with predator defense (Table 2) and by tolerance to acidic waters.

Boulton Lake. The population contains a stable polymorphism of "non-spined" and "spined" phenotypes, the former occurring in littoral and the latter in limnetic regions of the lake (Reimchen 1980).

Rouge Lake. As well as loss of the third dorsal spine, anal spine and lateral plates in this population, there is a reduction in the number of dorsal and anal fin-rays, reduction in the size of the cleithrum and the pterygiophores and development of a postcranial hump. Fifteen per cent of the fish have two dorsal fins, resulting from an absence of the middle rays. In a review of the literature (Wootten 1976), no sticklebacks with comparable characteristics are described.

Serendipity Lake. The majority of fish lack all vestiges of lateral plates and pelvic girdle. Dorsal spines, while present, are reduced to vestigial projections, and the cleithrum, supra-cleithrum and post-temporal bones are reduced in size. These fish closely resemble *G. aculeatus williamsoni*, found in California. Furthermore, the tolerance to acidic waters (pH 3.9) appears to be unparalleled for fish survival.

It is unknown whether these divergent populations and other endemic stickleback on the Queen Charlotte Islands have evolved from marine forms since the Wisconsin glaciation or whether these populations represent much older forms from a glacial refugium postulated for the region (Moodie 1984). No separate taxonomic status for these populations is currently planned; however, such a status may be warranted in the future when the full range of genetic variation in *Gasterosteus* becomes known.

Evaluation

At Boulton Lake, the habitat and the population size is stable. Rouge and Serendipity Lakes are going through a period of rapid habitat alteration due to the activities of the recently-introduced Beaver; because of the very small size of these two ponds, changes in pH, blockage of drainage, increased accumulation of organic debris and possible differences in predatory regimes may adversely influence the genetic structure and populations size. The stickleback populations in Boulton, Rouge and Serendipity Lakes can be designated rare with respect to the known variation in this species.

Acknowledgments

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Status of the Shorthead Sculpin, *Cottus confusus*, in the Flathead River, British Columbia*

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Peden, A. E., and G. W. Hughes. 1984. Status of the Shorthead Sculpin, *Cottus confusus*, in the Flathead River, British Columbia. Canadian Field-Naturalist 98(1): 127–133.

As of 1981, a large population of Shorthead Sculpin (*Cottus confusus*) occurred in the Flathead River system of British Columbia. The population could be considered "threatened" because of: 1. its restricted distribution; 2. lack of long term observations on population fluctuation; 3. field biologists' difficulties in distinguishing the species from the Slimy Sculpin (*C. cognatus*); 4. potential for large scale habitat degradation through impact of Sage Creek Coal Development or other developments affecting habitat and water quality. If the Sage Creek Coal Development restricts itself to the original proposal at Cabin Creek and Howell Creek, then sustainable populations could also survive at Sage, Couldrey, and Burnham creeks, as well as the main body of the Flathead River. However, population trends must be observed over a number of years before predictions can be made on the viability of such restricted populations. If Sage Creek Coal Ltd. follows through on a plan to redirect Howell Creek to a point further upstream on the Flathead River, such changes would, possibly, greatly affect the greater portion of the only Canadian population of *C. confusus*, but the results of such changes are not yet predictable.

En 1981, une importante population de chabots à tête court (*Cottus confusus*) peuplait le système de la rivière Flathead en Colombie-Britannique. Cette population peut être considérée comme menacée à cause de: a) sa répartition restreinte; b) le manque de données sur ses fluctuations à long terme; c) la difficulté des biologistes sur le terrain de distinguer l'espère du chabot visqueux (*C. cognatus*), et d) la menance d'une vaste dégradation de l'habitat suite à l'exploitation du charbon du ruisseau Sage ou à autres ouvrages influant sur l'habitat ou la qualité de l'eau. Si l'exploitation du charbon du ruisseau Sage se limite aux ruisseaux Cabin et Howell, conformément au plan initial des populations reproductrices pourraient survivre dans les ruisseaux Sage, Couldrey et Burnham ainsi que dans la partie principale de la rivière Flathead. Toutefois, if faut observer pendant plusieurs années les tendances de la population avant de pouvoir faire des prévisions sur la viabilité des populations aussi restreintes. Si la Sage Creek Coal Ltd. réalise son plan de dérivation du ruisseau Howell vers une partie plus en amont de la rivière Flathead, ces changements pourraient grandement influer sur la majeure partie de l'unique population canadienne de *C. confusus*, mais les résultats de tels changements ne sont pas encore prévisibles. [Traduit par R. R. Campbell].

Key Words: British Columbia, Flathead River, sculpins, distribution, population size and threatened, coal development.

The Shorthead Sculpin (*Cottus confusus*) is a little-known species of the Pacific drainage in Puget Sound and the Columbia River Basin and has only recently been recognized as a distinct species (Bailey and Bond 1963). It occurs sympatrically with the Slimy Sculpin (*C. cognatus*) and is very difficult to distinguish from it. Shorthead Sculpins are small fish (Figure 1) seldom exceeding 105 mm in length; the body is light brown with dark mottlings and some individuals show three dark bars under the second dorsal fin (McAllister and Lindsey 1959).

Distribution

The Shorthead Sculpin was described from the Columbia and Snake River systems in Idaho, Montana and Oregon as well as drainages of Puget Sound, Washington (Bailey and Bond 1963). Lee et al. (1980) have summarized the current knowledge of the species distribution. *Cottus confusus* occurs in the Flathead River of Montana and southeastern British Columbia in the Columbia River drainage. Bailey and Bond (1963) suggest some differences such as fewer individuals with a post-maxillary pore and a somewhat higher fin-ray count may indicate that populations in the Flathead River drainage are identifiable from other populations within the species.

Prior to 1981, only 26 specimens of Shorthead Sculpin were known from Canada (Peden and Hughes 1981). The British Columbia Provincial Museum made an extensive survey and collected approximately 400 individuals in the lower 24 kilometer reaches of the Flathead River and associated tributaries within British Columbia (Figure 2). Substantial numbers were found in the main portion of the Flathead River at elevations of 4500 ft. (1372 m), as well as in the lower portions of the following tributaries: Howell, Cabin, Burnham, Couldrey, Commerce and Sage creeks. Some were also found in Kishinena Creek, which flows across the international border before merging with the Flathead River, but samples are not large enough to determine the size of that population.

*Threatened status approved and assigned by COSEWIC 10 November 1983.

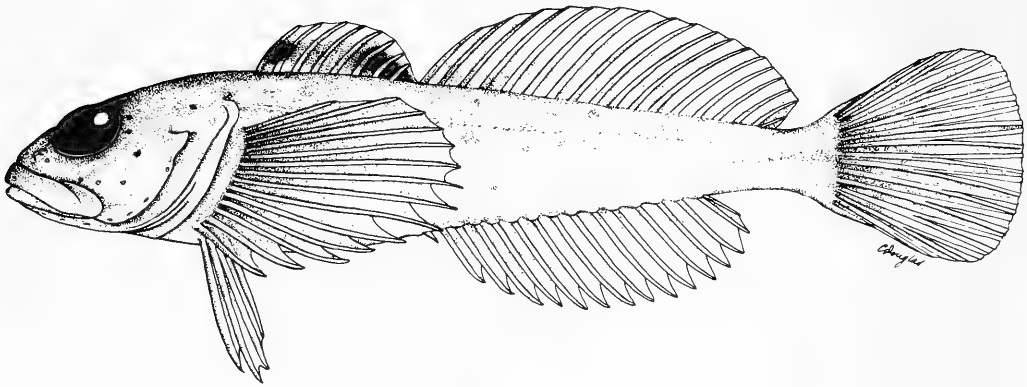

FIGURE 1. Shorthead Sculpin (*Cottus confusus*). Courtesy of D. E. McAllister, National Museum of Natural Sciences.

Upstream portions of the Flathead River, Commerce, Sage, and Kishinena creeks possess predominantly more Shorthead Sculpins than Slimy Sculpins and consequently this does not entirely support inferences of Bailey and Bond (1963), Stanford and Potter (1976), and Lee et al. (1980) that *C. confusus* occurs further upstream than other sculpin species. These authors probably refer to other syntopic sculpins in drainages from other parts of the species' geographic range outside Canada i.e., Mottled Sculpin (*C. bairdi*), Torrent Sculpin (*C. rhotheus*), Prickly Sculpin (*C. asper*), Coastrange Sculpin (*C. aleuticus*), etc., which are also known either further south or in portions of stream and river systems that are downstream from Shorthead Sculpin populations. Between 1980 and 1981, field crews of the British Columbia Provincial Museum did not find any changes in the zones of distributional overlap between Shorthead Sculpin inhabiting the Flathead River. Continued monitoring is needed to see if there are long term changes in distribution.

Protection

No specific or special measures for Shorthead Sculpins are now in force. Existing federal and provincial fish and wildlife, water quality, resource management laws, etc., probably offer some minimal protection.

Population Size and Trend

On the basis of approximately 400 specimens of Shorthead Sculpins captured in August 1981 (Figure 3), we believe that there is a substantial population in the lower Flathead basin of British Columbia. Sculpins were caught using an electrofisher (Smith-Root, Vancouver, Washington, powered by a 12-volt battery and operated at 425 volts with a pulse of 7 milliseconds and a rate of 70 pulses per second). Shorthead Sculpins were drawn to the equipment from distances of one to two metres and at a rate of two to eight fish per 100 seconds. These rates of capture were considerably lower than the 14 specimens of Slimy Sculpins per 100 seconds captured in upstream areas. Therefore, population densities are probably lower per unit area of the Flathead River for Shorthead Sculpins than for Slimy Sculpins.

The survey also suggested that streams tributary to the Flathead may also contain substantial numbers of Shorthead Sculpin, but there must be samples taken throughout the year if we are to determine whether the populations are resident or are migrants from downstream. Much of the Flathead River is relatively inaccessible and data is insufficient to estimate population size or trends. More investigations of juvenile Shorthead Sculpins are needed; if juveniles are as few as our collections suggest, the population is in trouble.

Habitat

Cottus confusus is reported to inhabit riffles of small, cold streams (Bailey and Bond 1963; Lee et al. 1980). In August 1981, we found the species to be most abundant in areas of stones where the bottom was not heavily sedimented and there was a slow current, and not necessarily in riffles. In many areas the preponderance of stones breaking the surface provided a complicated flow pattern such that specific flow rates inhabited by sculpins could not be easily measured. The Shorthead Sculpin is sympatric with several species of the genus (*Cottus*) in other parts of its range and with the Slimy Sculpin in the Flathead River.

Much of the Flathead River and tributaries below 4500 ft. (1372 m) in Canada meander through a broad valley. In the areas we visited, riffle areas had a bot-

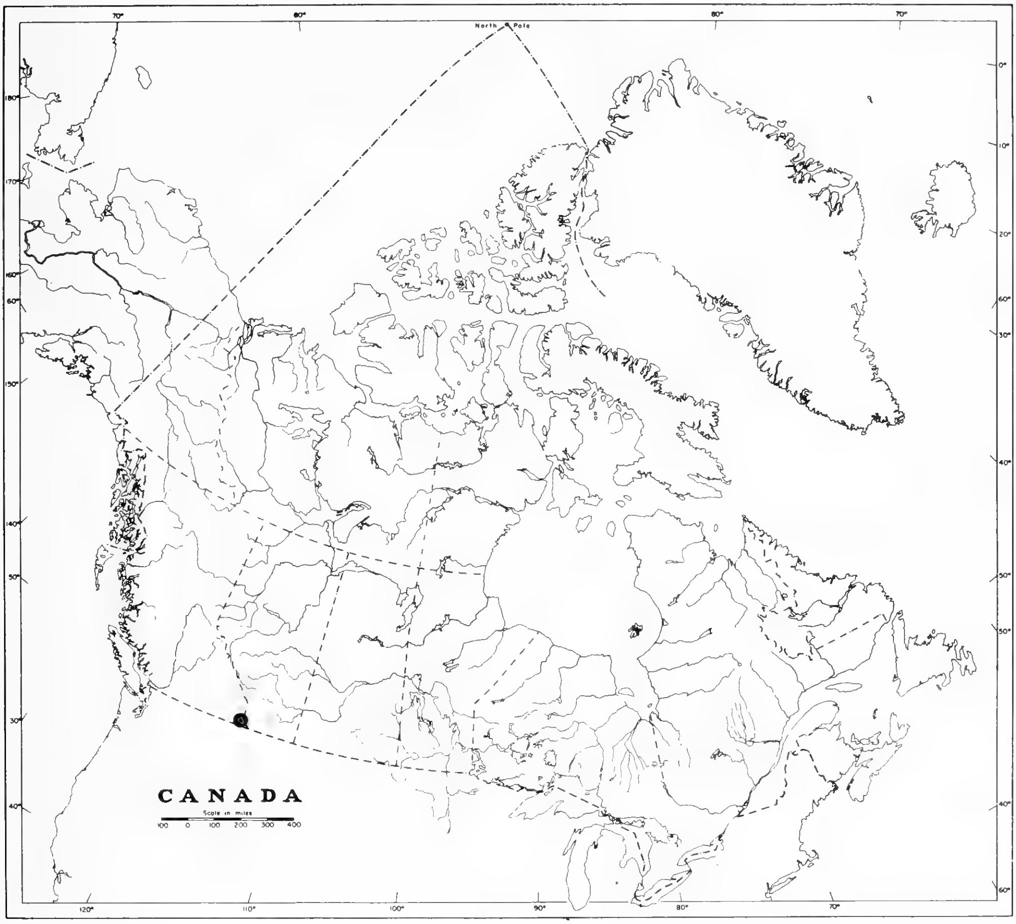

FIGURE 2. Canadian distribution of the Shorthead Sculpin. Courtesy of D. E. McAllister, National Museum of Natural Sciences.

tom composed of large-to-small polished rocks or pebbles whereas intervening pools often had more sediment. Sculpins were most abundant near the riffle areas but, because the number of Shorthead Sculpins was few, more studies are needed on their habitat competition with the Slimy Sculpin. Shorthead Sculpins generally occurred further upstream than the Slimy Sculpins and we assume they prefer slightly cooler waters, although this has not been confirmed.

In general, the water of the Flathead River is fed by mountain streams and in summertime is clear, but we do not have data on the extent of spring run-off and flooding. According to the British Columbia Water Investigations Report (1978), segments of the Flathead River, Cabin and Howell creeks known to possess Shorthead Sculpins have alkalinities ranging between 88 and 143 mg/L., pH between 7.9 and 8.6, and turbidity values expressed at JTU between 0.3 and 68 (with a mean of 10.6 or lower).

In any mountain streams, such as those of the Flathead River, periods of snow-melt provide a big impact on stream ecology. Hinton et al. (no date) have provided summaries of stream-flow rates for the Flathead but, unfortunately, no information exists for Sage Creek, which might act as a reservoir for shorthead populations, if the remaining Flathead basins are altered by Sage Creek Coal Development. Most important, if *C. confusus* spawns in mid-April similar

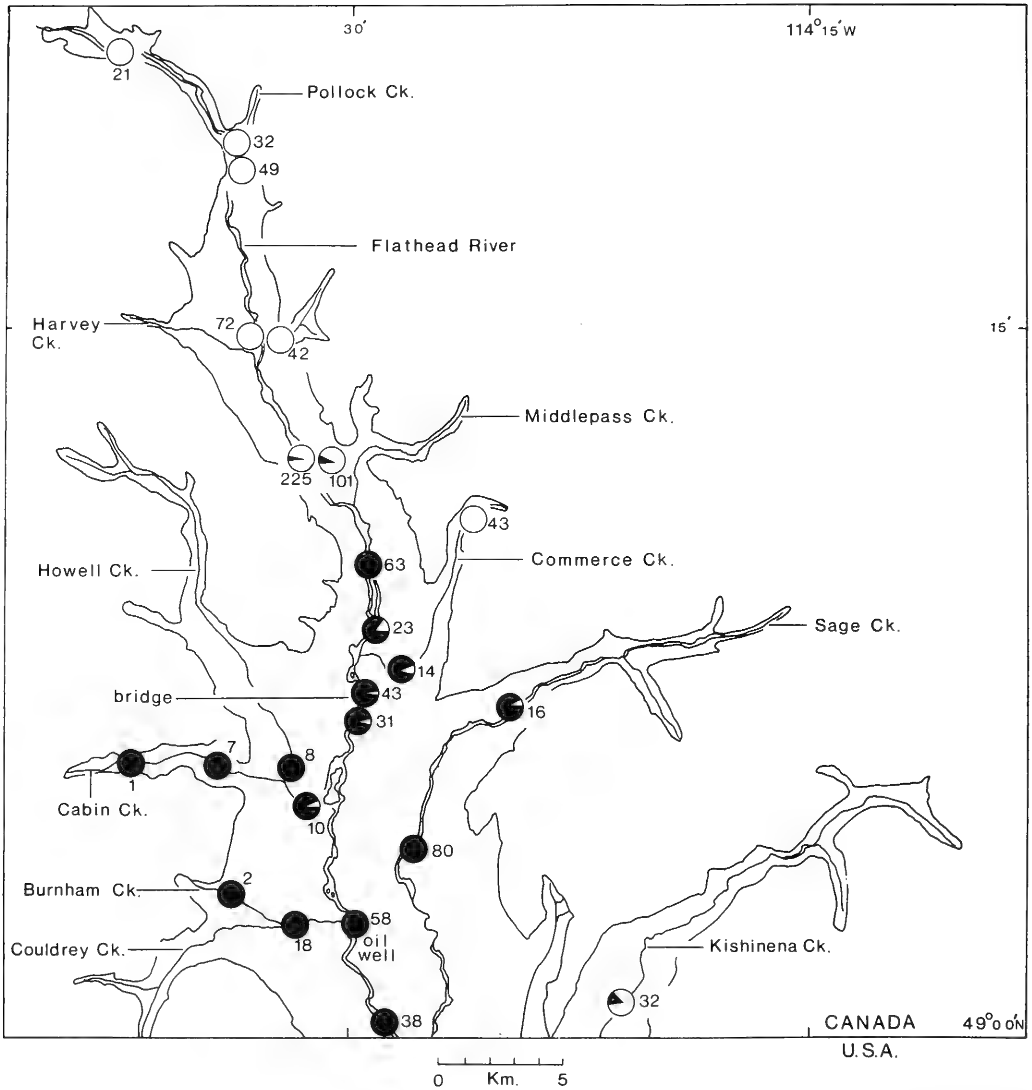

FIGURE 3. Distribution of sculpins in the Flathead River of British Columbia, Canada. The dark portion of each distribution spot indicates proportion of *Cottus confusus* in sample. The pale portion indicates proportion of *C. cognatus*. The number of specimens in each sample are indicated. The 1500 m elevation contour is indicated around the basin. *Cottus confusus* was generally found below 1372 m.

to the Big Lost Creek populations in Idaho (Gasser et al. 1981), this would coincide with spring flooding and the impact of such flooding in relation to sculpin breeding behaviour is not understood. Sheehan et al. (1980) should be consulted for other aspects of water quality in the Flathead River.

There are no adequate observations over a long period of time to establish trends or fluctuations of critical habitat. The exploitation of coal deposits in the Sage Creek Area will undoubtedly eliminate habitat. There has been extensive logging and/or forest fires in the Flathead River basin, but we have no basis to determine the effect on, or rate of, habitat change; but development of coal deposits can't help but speed up the rate of habitat loss.

General Biology

Lee et al. (1980) indicate sexual maturity is reached at two or three years of age, whereas Gasser et al. (1981), the compilers for Lee et al. (1980), reported age class 3 fish with ripe eggs. Lee et al. (1980) suggest *Cottus confusus* spawns on the undersurface of rocks in rubble areas and if breeding habits are similar to other *Cottus* sp. (*see* Lee et al. 1980), then males would be expected to accompany egg masses in which one to four females may have contributed (Bailey 1952). No information is available on breeding frequency of Shorthead Sculpins in the Flathead River in Canada. Gasser et al. (1981), found that shorthead females breed every April, after they reach maturity. From previous collections we have found that the number of eggs per female varies with size (minimum of 128 eggs in a female of standard length of 55 mm to a maximum of 690 eggs in a female of 99 mm). Our meager data did not allow compilation of a fecundity ratio such as that compiled by Gasser et al. (1981) for the Big Lost River in Idaho. They found a fecundity to standard length ratio of F = 14.15, S. L. - 531.

Results of length frequency analysis of age structure and size composition on Canadian populations are inconclusive because of the paucity of specimens and lack of clear-cut size groupings. Our studies have suggested a faster growth rate for Canadian populations than that indicated in Idaho by Gasser et al. (1981) with fish in the third year class attaining lengths of 60 to 70 mm. Only 14 specimens of the first year class have been obtained and their origins have yet to be explained. Males may grow faster and mature earlier than females (two years as compared to three years) in contrast to the results of Gasser et al. (1981) who found no sexual difference in size composition. Current data does not indicate if the apparent disproportionate sex ratios of Shorthead Sculpins in Canadian waters is due to a further growth rate of males, differential mortality between sexes, or differential habitat preferences.

No valid observations have yet been made on Shorthead Sculpins in the Flathead River system and mortality replacement information cannot be determined until the source of juveniles is resolved. Similarly, no information exists on species movement including migratory spawning habits, but there may be some movement if the report of Hinton et al. (no date) refers to Shorthead Sculpins and not Slimy Sculpins. The degree of tolerance to stream disturbance through mining or logging has not been determined, although silting from logging operations (Hinton et al. no date) has not yet decimated the species in its known habitats.

Analysis of stomach samples indicated a predominance of aquatic insects in the diet. Other freshwater invertebrates other than insects may also be important along with small fish.

Limiting Factors

The most serious threat to the Flathead River population of Shorthead Sculpins is a proposal for development of the Sage Creek Coal Ltd. coal resources. A new townsite, roads, transmission lines, and diversion of Howell Creek to a point further upstream on the Flathead River are proposed. Both use of ground water reserves and building of new impoundments that could drain into the Flathead River is possible. The terrain would be greatly changed by removal of rubble during the mining process. A full overview of the potential for habitat change and need for its protection is available in Hinton et al. (no date).

Due to the lack of juvenile specimens in collections to date, and the proposed exploitation of coal resources in the area, Canadian populations of Shorthead Sculpins may already be in serious trouble.

Special Significance of the Species

The majority of field biologists have not been able to identify the Shorthead Sculpin adequately. This lack of recognition could facilitate the species' decline if society or the scientific community are not aware of the species' uniqueness as part of Canada's natural fauna.

Surveys by the B.C. Environmental Land Use Committee and various Fish and Game agencies have not included the species in their inventories. In particular, we draw attention to such reports as Hinton et al. (no date), or that of Sheehan et al. (1980). The latter states on p. 122 "Levels of metals in the Slimy Sculpin (= *C. cognatus*) also indicate the lack of a water quality problem as the heavy metal levels . . .". On p. 16 they state "Slimy Sculpins were caught by personnel from the Cranbrook Regional Office of the Fish and Wild-

life Branch." We are certain that such studies included significant numbers of two sculpin species since station numbers (#3, 6, 7) listed in their report (p. 46) are from localities where we found nearly pure populations of Shorthead Sculpin (= *C. confusus*).

Evaluation

As of 1981, a large population of Shorthead Sculpin occurred in the Flathead River system of British Columbia. The population could be considered "threatened" because of:

1) its restricted distribution;
2) lack of long-term observations on population fluctuation;
3) field biologists' difficulties in distinguishing the species from Slimy Sculpins;
4) potential for large scale habitat degradation through impact of Sage Creek Development or other developments affecting habitat and water quality.

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We are grateful to Gordon Green and Doug Sage, of the British Columbia Provincial Museum, who assisted the field party and J. D. McPhail, of the University of British Columbia, and D. E. McAllister of the National Museum of Canada, who provided us with information and/or specimens. F. Vivanti, Sage Creek Coal Limited, Vancouver, provided information and a copy of the Preliminary Environmental Impact Assessment of the Proposed Sage Creek Coal Project, Stage 1 Report by Hinton et al. We would also like to express our thanks to Lynne MacDonald of the British Columbia Provincial Museum for typing the manuscript.

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Book Reviews

Zoology

The Cotingas

By David Snow. 1982. British Museum and Cornell University Press, Ithaca. 203 pp., illus. U.S. $45.

To North Americans, Cotingas are exotic tropical birds noted for their spectacular plumage and equally spectacular courtship displays. This book is a comprehensive review of cotingid biology which emphasizes the diverse and intriguing aspects of the family. The information is drawn from published accounts and Snow's own 20 years of study on these birds. It is mainly a technical treatise emphasizing detail, but because of good organization, an attractive layout and excellent plates it should appeal to a broad spectrum of professional and amateur ornithologists.

The book has two major sections. The first includes four chapters which are a synthesis of the major features and trends in the evolution, biogeography, ecology, and behaviour of the family. The data backing up the synthesis are presented in the second section, which makes up about 75% of the book. It is devoted to accounts of all 35 genera, with a consideration of all included species. Typically a discussion of distribution, ecology, behaviour, breeding and annual cycle, plumage and moults, and physical characteristics are included for each species. I found the accounts of the behaviour and ecology to be very readable and easily comparable between species. Information about plumages, distribution and annual cycle was easily extracted. Although Snow wrote most of this section, a few accounts are contributed by people with relevant field experience. The accounts are up do date, for example Scott and de Brooke's observations of the Grey-winged Cotinga, a bird first described in 1980, are included. In every entry the inclusion of excerpts from field notes, exact dates and locations and actual measurements reflects the author's effort to convey accurate information. Between these two major sections there is a good balance of synthesis, which allows comparisons of similar trends in other animal groups, and data presentation which allows an understanding of the natural history of each species.

Three appendices (a taxonomic summary, the derivation of scientific names and notes on the distribution maps) and a comprehensive reference list conclude the book.

Snow's book compares favourably with other bird family monographs published by Cornell University Press, despite the relative paucity of information on Cotingas compared to doves or falcons. Its strengths lie in its attention to detail, good organization and careful synthesis. The Cotingas will be of value to ornithologists with interests in the neotropics, passerine systematics and behavioural ecology, and to amateurs, like myself, with a taste for the exotic.

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Islands of the Seals: The Pribilofs

Edited by the Alaska Geographic Society. 1982. Alaska Geographic Quarterly. Volume 9, No. 3. 128 pp., illus. U.S. $11.95 plus U.S. $1 postage.

Although remote, the fabulous marine riches of the Bering Sea and northern Pacific Ocean were ruthlessly plundered by Europeans during the late 18th and early 19th centuries. Populations of Steller's Sea Cow, Sea Otter, Walrus, and Northern Fur Seal were extirpated or reduced to such low levels that commercial exploitation became, for the most part, no longer possible. So great was the initial wealth that on the Pribilof Islands, 17 years after their discovery by Europeans, 700 000 accumulated Northern Fur Seal pelts were found spoiled, jettisoned at sea, and still the harvest continued apace. In order to reap the natural resources native people were frequently enlisted, either through free-trade or enforced labour, as the needs dictated. Whole villages of indigenous peoples were cavalierly relocated to allow exploitation of newly discovered riches. Such unappealing antecedents form the historical background of the western portion of Alaska.

This most recent publication by the Alaska Geographic Society offers the armchair browser a multifaceted glimpse into the turbulent history and present status of the tiny Bering Sea archipelago known as the Pribilofs. Human association with these islands has always revolved around their abundant wildlife. Accordingly, this volume's initial focus is upon the flowering plants, the birds, and the abundant Northern Fur Seals. All of these appear seasonally on the islands. For the naturalist, these accounts may con-

jure thoughts of travelling to the Pribilofs with that other seasonally appearing entity: tourists. The second focus is upon the people who live on St. Paul and St. George Islands, people inextricably entwined with the living resources of the islands and the surrounding sea.

The nine chapters are written by different authors. The style, degree of detail included, and intended audience of those chapters vary markedly. The result is a disjointed text in which continuity of thought is somewhat difficult to maintain. Perhaps the harsher hand of editorial control should have been applied. Clearly the authors are not professional writers, this is not a slick, tightly packaged monthly magazine. Yet some of the authors do convey their thoughts with passion and intensity. Indeed, the editor has inserted comments through the body of the text cautioning the reader against overly partisan views expressed by individual authors. The result is a basically popular account with a welcome analytical slant. The candor of authors discussing land claims of native people or the management of living resources in the latter portion of the book is moving.

Here is a long and detailed account of the Fur Seal harvest, from considerations of what constitute biologically sound management practices to an outline of the fine degree of division of labour among sealers during the slaughter. Children are directed in the collection of baculi and testes from carcasses, for sale to the folk medicinal market. The descriptions and accompanying photographs do not try to euphemistically cover up details of the harvest. The operation is humanitarian and is conducted in a skilled fashion by professional workers. To the extent allowed by market forces, almost all parts of the seal carcasses are used.

Sealing operations in Canada today tend to be conducted in a highly polarized atmosphere with harvest details clouded by loud claims and counter-claims by those for and against the harvest. The Alaskan example is refreshing in its forthrightness.

This volume recounts the story of the human inhabitants of the Pribilofs in their struggle to survive and retain dignity in changing times. The last line of the story may be dictated by the very remoteness of the islands which gives them much of their charm. Exports from the Pribilofs incur large freight costs; import costs are similarly high.

Overall, *Islands of the Seals* is an attractive book with more space devoted to photographs than to text. The quality of the colour photographs and their reproduction is somewhat variable but, given the book's cost, generally good. The selection of historical photographs is excellent. The Alaska Geographic series has been of consistently high quality, the current issue being no exception.

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Saskatchewan Cougar — Elusive Cat

By T. White. 1982. Special Publication No. 14. Saskatchewan Natural History Society, Regina. 80 pp., illus. $5.00.

Whenever the name "cougar" or "mountain lion" is mentioned with respect to Canada's largest member of the cat family, images of rugged canyons and craggy mountains most often come to mind. Seldom would a person conjure up a prairie scene or even a forest area in northern Saskatchewan as a place where cougars can be encountered. Yet these are places where people have unexpectedly come upon this secretive animal.

Tom White, an architect living in Regina, Saskatchewan, has for several years been documenting the occurrence of cougars in Saskatchewan and this book is the result.

The contents of the book include a brief Introduction; a description of the cougar with comparisons between the cougar, lynx, and bobcat; Assessment of Cougar Reports; Historical Records; Cougar Habitat and Movements in Saskatchewan; Tracks and Kills; Saskatchewan Cougar Specimens; Saskatchewan Cougar Reports; Conclusion; References; and five Appendices.

It is certainly easy to criticize a book of this nature, such as the inconsistent use of scientific names on pages 5 and 77, but I do not believe that such is constructive or necessary. I would, however, like to point out a few things that could have been done to improve the flow of the book. I feel that the organization of the various sections could have been improved. For example, the sections on Historical Records and Saskatchewan Cougar Specimens should have been together as could the sections on Assessment of Cougar Reports and Tracks and Kills.

The bulk of the book, 37 pages, is a compilation of reports with a map of Saskatchewan indicating the location of these reports. There is great variation in the length of these citations. Some are not much more than a line or two, while others are several paragraphs

long. They do, however, provide the reader with, in some cases, a "feel" for what the reporter experienced when a cougar was encountered. They also give the reader information on where in the province cougars have been seen.

I do have two points to raise that I feel could give readers erroneous impressions. In reporting on the method of hunting and killing by cougars, White compares it to the method used by wolves. White perpetuates the idea that wolves hamstring their prey. In his book on the Wolf, Mech (1970) points out that such a practice would be extremely dangerous to the wolf and there is also no evidence from wolf kills to support the idea that hamstringing takes place. The other point I found objectionable has to do with the caption of the photograph on page 27. The phrase ". . . blood sucked dry" could easily be construed to mean that cougars kill only to "suck" blood. That cougars consume the blood of their prey is not in question, but I doubt if they kill an animal and "suck" it dry of blood. Probably the blood is lapped up along with other body fluids as the cougar consumes its prey.

White's purpose in writing this book is to "generate interest in the cougar and [to] facilitate its identification." Anyone in Saskatchewan who purchases this book, I believe, will certainly have their interest in cougars increased. I do not feel, however, that the descriptions given of either the physical features of the animal or its tracks, will necessarily "facilitate" in the identification of the cougar.

If a person wants to learn something about the biology of the cougar, I cannot recommend this book. If, however, a person is interested in the distribution of the cougar in Saskatchewan this is THE book to buy. The $5.00 cost of Saskatchewan Cougar — Elusive Cat makes it readily affordable. The Saskatchewan Natural History Society and Tom White should take pride in providing an informative book on such a secretive animal and providing it at such a reasonable cost.

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A Bibliography of Alberta Ornithology

By Martin K. McNichol, Philip H. R. Stepney, Peter C. Boxall and David A. E. Spaulding. 1981. Provincial Museum of Alberta Natural History Occasional Paper Number 3, Alberta Culture, Edmonton. ii + 377 pp. Free.

The *Occasional Papers* series is produced by the Alberta Provincial Museum without normal editing procedures. They argue that the small technical and production errors that will inevitably result from this are compensated by the rapid dissemination of important information. It's unclear, however, why there would be a need to produce a bibliography in this manner. The information would surely be no less significant next year or the year after. With this in mind I found the many problems with this ambitious effort difficult to accept.

The basic structure is clear enough. The bibliography begins with a brief history of ornithological study in Alberta. This is adequate until the post-war years when details become less precise than for 18th Century references. The absence of any reference to Godfrey's (1966) *Birds of Canada*, for example, is hard to understand. So too is the lack of any reference to the efforts of Calgary's R. Butot who has 98 citations in the text!

The historical section is followed by an unconvincing explanation for the complicated presentation of the information. The bibliography is divided into seven sections. One of these sections (the 'Cited References') is sub-divided in 10 subject headings and one of these is further subdivided into four additional subunits! To further add to the confusion, each Section has separate pagination (e.g. page 1-1, 2-1, 5-1, etc.).

The latest (Fourth) edition of the Alberta bird checklist precedes the bibliographic citations. As this was recently published separately (see *Canadian Field-Naturalist* 96: 372 (1982) for a review) its presence here seems to be redundant and unnecessary.

The bibliographic citations list — in alphabetical order by author — constitutes the bulk of the volume. Only a very small proportion of the citations are annotated. Thus, we are left to speculate what birds in 'Field Trip Reports' (page 4-35) and 'Report on Gun Club slough' (page 4-96) are being referred to. Similarly, the Alberta significance of an (unannotated) citation entitled simply "Chimney Swifts" is unspecified.

Any bibliography must, inevitably, miss some titles but this one has an inexcusably high number of

'misses'. A paper I wrote on Blue Jays (*Alberta Naturalist* 7: 285-286 (1977)) was omitted, for example, while a subsequent paper that cited it (*Alberta Naturalist* 9: 18-21 (1979)) was included. (Rule number one for bibliographers . . . never miss the titles of reviewers!). Of much greater significance is the omission of older (turn-of-the-century) papers. A quick review of J. M. Gillett's (1980) *Transactions of the Ottawa Field-Naturalist's Club and the Ottawa Naturalist Index* uncovered several Alberta references that are omitted in this volume. An astonishing omission involves the classic *Catalogue of Canadian Birds* by John Macoun. (It was produced in three volumes between 1900 and 1904 and should not be confused with the 1909 volume of the same title that was produced by John and James Macoun — and which *is* cited in this bibliography). I could easily list many other omissions, all of which throws serious doubt on the comprehensiveness of this work).

Just as serious as the incomplete citation listing is the very inadequate index. It applies only to the 'Cited References' section and only considers bird names and authors (separately). There is no cross-referencing nor is there a geographic index. Only common names are used (". . . to help the amateur . . .") but this hardly achieves its purpose when the unannotated titles employ scientific names only (5 out of 10 citations on page 4-7, for example). The unidentified species in ambiguously titled papers (such as those referred to above) are not included in the index. Most limiting (and perhaps fatal) to the usefulness of this index is its arrangement by adjectives rather than by noun. Thus, while Bald Eagle is listed with B's (between Baird's Sparrow and Band-tailed Pigeon), Golden Eagle is found in the G's (between Glaucous-winged Gull and Golden-crowned Sparrow). One can easily imagine the difficulties in reviewing groups like ducks or sparrows! Such cumbersome organization and the errors and omissions virtually assure that the reader must examine the citations section page by page.

This bibliography is incomplete and ill-conceived and awkwardly presented and reads like an indiscriminant computer regurgitation. I cannot recommend it.

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Atlas of European Trichoptera

By Hans Malicky. Junk, The Hague, The Netherlands (Canadian distributor, Kluwer, Boston). xii + 298 pp., illus., Dfl. 175 (approx. U.S. $76).

This book represents the first comprehensive treatment of the adults of the European caddisfly fauna since McLachlan's revision and synopsis appeared over 100 years ago. As such, it is an important contribution that should serve as an invaluable aid in the study of European Trichoptera. Intended primarily for the purpose of identifying adult caddisflies to species, Dr. Malicky's atlas contains almost no text, and there are no written descriptions or keys to species. Identification is supposed to be accomplished through comparison of the specimens at hand with the thousands of illustrations that comprise the bulk of the book. As an aid in guiding the user to the correct family or genus, a table is presented on page 2 that gives different combinations of the various states of certain characters: tibial spur formula, presence or absence of ocelli, and the number of segments in the maxilary palpi of the males, with a corresponding list of the taxa that possess each combination and the page on which each taxon is found. A similar table is given on page 151 that identifies the genera of the large family Limnephilidae by the tibial spur formula. Once a user has found the correct higher category, the next step is to compare the cleared genitalia of the specimen with the illustrations until a match is found. Several aids to identification are provided on each page. Across the top of the page, or at the start of each group of illustrations when a new taxon begins in the middle of a page, is a single line that gives the family and genus (or genera) names, the sex treated on that page (males and females are treated separately in most cases), the number of segments in the maxillary palpi of the males if fewer than five, special symbols that warn of difficult identifications due to the similar appearance of closely related species, or if the other sex is unknown or poorly known, the spur formula, and the presence or absence of ocelli. For each species the name, author, and date of original description are written above the illustrations, followed by the range of forewing lengths in millimeters, and an abbreviation describing the known distribution of the species when this information is useful in identification. The illustrations include a lateral view of the genitalia, usually a dorsal, caudal, and/or ventral view, and in many cases details of important structures and examples of variation. Wing venation, maxillary palpi, antennae, or a dorsal view of the thorax also are illustrated when appropriate. Symbols are used to highlight diagnostic characters, point out distinctions

between closely related species, and to warn of difficult choices or of deficiencies in our knowledge of certain taxa. This procedure is described in a brief introduction entitled "How to use this book." In order to minimize language difficulties, the introduction, explanations of symbols, tables, and a page illustrating basic caddisfly morphology are written in English, German, and French.

This book is an important contribution to the study of caddisflies because it brings together in one volume illustrations of the more than 1000 species now known from Europe. However, the scope of the book is also its weakness since this has caused the author to severely limit the text and to take illustrations from the literature rather than produce all original artwork. By eliminating descriptions and diagnoses useful information has been excluded, although efforts have been made to present the illustrations as clearly and as informatively as possible through the use of symbols and the depiction of variation. By using illustrations from many different sources, however, an uneven level of quality has resulted that not only makes it difficult to use the book, but also detracts from its appearance.

Further, on the page explaining the layout of the illustrations and the use of symbols, the author has inexplicably used fanciful combinations of taxa rather than legitimate examples; there is no reason for this, and it might be confusing to someone not familiar with caddisfly systematics. Also, in most instances, illustrations of the males of a genus are grouped together prior to the illustrations of the females of the same genus, making it more difficult to find the illustration of the opposite sex when they are separated by many pages and are not presented in any logical order. In a few instances, such as the first page treating the males of the genus *Glossosoma,* the page on which the females begin is given at the top of the page, but the corresponding information is not given at the beginning of the section on the females of *Glossosoma*. There is no apparent reason for this information to be given in the few instances where it appears and not anywhere else.

The Atlas of European Trichoptera is a good book by one of Europe's leading authorities on caddisflies. Ultimately, European users will determine how successful Dr. Malicky has been in achieving his aim of producing a workable source for the identification of adult European caddisflies. For North Americans, most of whom have limited access to material from Europe, the chief value of this book lies in the gathering together in one volume of illustrations of the known European fauna, making it easier not only to compare North American and European taxa but also to gain easier entry into the vast literature on the subject. I recommend the *Atlas* to anyone with a serious interest in the systematics and biogeography of Trichoptera.

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The Northern Yellowstone Elk: Ecology and Management

By Douglas B. Houston. 1982. Macmillan, New York. xvii + 474 pp., illus. + plates. U.S. $48.

Wildlife management in national parks is a controversial, poorly understood subject that only recently has been accorded rigorous scientific scrutiny. Perhaps the most widely publicized parks management controversy in North America concerns the large mammal system of Yellowstone National Park, specifically, the controlled conservation of ungulates and predators. Douglas Houston tackles the ungulate control controversy head-on, and his book must be considered an important milestone in the evolution of sound planning policies in national parks.

The system of wildlife management which has developed in Yellowstone National Park since the early 1900's is not unlike that of many North American natural parks and reserves. Most such areas have been politically alienated from adjacent territory artificially creating "transboundary wildlife populations" requiring special consideration because animals range over areas with differing land use objectives, i.e. consumptive versus preservation.

Houston systematically attacks the validity of wildlife population reductions in national parks. Elk reductions have been used to compensate for human interference with elk ecology such as predator control, habitat destruction, and disruption of traditional seasonal movements. These disturbances supposedly resulted in too many elk on park ranges, which led to deteriorating range conditions and competition with other less numerous ungulates. Over the past 20 years, wildlife biologists have hotly debated the need for interference management in Yellowstone National Park and Houston argues that such action has done much harm, but nothing to improve the situation.

In the interest of ecologically sound parks management, Houston's objective was to study the nature of existing vegetation-ungulate relationships to

determine if population reductions were necessary in the park. To accomplish this he had to test the hypothesis that "vegetation-ungulate equilibria appropriate to the park were possible without cropping ungulates in the park", a task he realized would be "operationally difficult" to test. Alternatively, he exhaustively researched historical records of changes in elk numbers, vegetation, and associated fauna to test the hypothesis that "vegetation on ranges occupied by elk did not depart from pristine conditions because of grazing by elk." Termination of park elk reductions commencing in 1969 allowed the author to monitor the impact of an expanding elk population on range resources and other species sharing the Yellowstone environment. These are just two of several innovative, scientifically sound approaches the author adopted to efficiently utilize the enormous amount of historical data plus that which he and other Park Service biologists generated through intensive research of the Yellowstone ecosystem from 1964 through 1980.

In spite of what Houston often refers to as inferences based on "a sticky blend of data and guesswork", he successfully pulls together the pieces of a giant puzzle to test the hypotheses he specified were important for evaluating the need for elk herd reductions in the park. Nevertheless, important biases, conflicting data, and alternative interpretations are never overlooked.

The data as discussed in text are presented under the major headings of population trends, population dynamics, seasonal distribution, physiological ecology, behavior, and habitat relationships of elk, and also vegetation statistics and dynamics, interspecies relationships in the herbivore guild, and elk-carnivore relationships. Therefore, the book provides basic information on elk ecology and their role in the ecosystem in addition to aspects of their management.

Organization of this book has been tailored to satisfy various levels of readership. Realizing that the magnitude of the data base and the technical level of statistical analyses would divert attention from important points of discussion and conclusions, the author relegated details of analytical procedures and data summaries to a series of ten appendices. Each chapter of text is a logical summary of data to illustrate important concepts followed by an interpretive discussion and summary of conclusions. These latter sections will be much appreciated by those using the book for reference purposes and further review.

The highlight of this book is Chapter 12 — Management. Houston presents several challenging and possibly provocative recommendations concerning fire and vegetation management, elk management that has to acknowledge both the preservation goals of the national park plus the consumptive use of elk and depredation problems on lands adjacent to the park, reintroduction of wolves and other extirpated species, and monitoring and research. A major point of the author is that all management be regarded as experimental; programs must be scientifically designed and monitored concurrent with frequent review for consistency with objectives and to test hypotheses.

This book is obligate reading for park and natural area managers, and federal, provincial and state wildlife biologists. The application of ecological rationale to wildlife management should attract wide attention in academic and natural history circles. The book is a testimony of the need for long-term research to test and refine management procedures in national parks.

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L'exploitation des grenouilles au Québec

Par Alice Marcotte. 1981. Rapport Technique No. 06–34. Ministère du Loisir, de la Chasse et de la Pêche, Montréal. xiii + 75 pp. illus.

This publication is the author's M.Sc. thesis, issued as a technical report by the Quebec government. Its purpose was to collect information on the utilization of frogs by humans: the uses frogs are put to, hunting, import and export, regulations pertaining to the use of frogs, the raising of frogs and the problems associated with these activities. Information was obtained from questionnaires sent to hunters, dealers and institutional consumers of frogs. Replies were received from 14 hunters, 52 dealers and 77 consumers and cover utilization for food, research and teaching. The publication succeeds in its aim of assembling available information on the commercial use of frogs in Quebec. Anuran biology and the status of populations are not covered, although studies in these areas are planned.

The report mentions the unreliability of supply of wild-caught Canadian frogs (all frogs' legs sold commercially are imported, although specimens for teaching and research are often taken locally). The frog trade in Quebec is unregulated, and the animals are

often received by the user in poor condition. Several pages are spent in detailing the requirements of commercial frog-raising operations, and the impracticability of such enterprises in Canada is made evident.

The author includes a mention of the need for legislation concerning both the harvesting and selling of frogs and management of their habitat. Amphibians have been sorely neglected in legislation and management strategies and this report illustrates the need for attention to that part of the fauna.

This publication contains little of interest to the average field naturalist but would be useful to those concerned with wildlife management and policy development.

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Der Bartkauz [The Great Gray Owl]

By Heimo Mikkola. 1981. Die Neue Brehm-Bücherei [The New Brehm Library], Ziemsen Verlag, Wittenberg Lutherstadt. 124 pp., illus. $7.27.

The New Brehm Library, in East Germany, are publishers of zoology reference books. This book, a substantial technical treatise, is loaded with information. The photos are marvelously instructive. I was delighted by the series of snow-plunging photos, the most informative I've yet seen. Included is a photo by Robert R. Taylor of the imprint of a snow-plunge by a Manitoba Great Gray Owl.

Owing to some unfortunate circumstances, it took more than a year to have this book, which is in German, translated into English; otherwise I would have read it and reviewed it earlier. Incidentally, Der Bartkauz, or Bearded Owl, the German name for the species, is in reference to the "beard" or dark wedge of feathers under the bill, a feature, according to the author, larger in the European subspecies than in the nominate North American counterpart.

Heimo Mikkola is the foremost Great Gray Owl expert, having spent more than 10 years studying them in his native Finland and elsewhere. Since 1965 he has investigated especially the distribution, ecology, and nutrition of the Finnish Great Gray Owl. Although this bird — the Eurasian subspecies of the circumpolar Great Gray Owl — is found in several countries in Europe, it is especially abundant in Sweden and Finland. The author reports that in Finland alone, from 1953 to 1977, 287 nests of the Great Gray Owl were found. (Note that Michael Collins, in an MSc study of the species — University of Manitoba, 1980 — reported only a little over 130 nest records altogether for this species in its North American range.) From 70 nests the clutch size is known, and from 68 nests the exact number of nestlings is known. From 37 nests Mikkola collected food samples with altogether 2949 prey animals recorded. He also examined the stomachs of 54 birds from Finland outside of the breeding season and with the help of these identified 255 prey animals. In addition, information was available from 23 nests in Swedish and Finnish Lappland (studied by others).

"In Fenno-Scandia small mammals are the chief nourishment of the Great Gray Owl during the brood season . . . Out of altogether 5177 prey animals, the small mammals make up 5095 (98.4%). The most important prey species is a vole or field mouse (*Microtus agrestis*) with 66.2% . . . The main food source of the Great Gray Owl in the U.S.A. and Canada is the species of *Microtus* (*M. pennsylvanicus*), which is also the most abundant of its kind in North America."

The table of contents lists 16 topics, covering such diverse subjects as: taxonomy, morphology and anatomy, sexual dimorphism, skeletal features, distribution, living space in summer and winter, density, faithfulness to nesting localities, migration, behavior, biology of nutrition, food fluctuations, food in North America and Asia, biology of reproduction, territory, nest and biotype, clutch and eggs, development of young, pair formation, cannibalism, illnesses, enemies and competitors. Hardly anything is missing from this instructive report which supplies a lot of substantive data on the above and other subjects.

The book includes an extensive list of European and North American literature, all of which has clearly been reviewed and used in the preparation of this monograph. The author, despite his obvious familiarity with the Great Gray Owl, cautiously asserts that "it would be premature to assume, however, that all the problems about the Great Gray Owl have been solved. Many questions about the ecology of distribution of populations, the biology of incubation and brooding, and especially ethology are far from being solved. Above all, further comparative studies of different populations, as, for example, between Canada and Europe, are important."

Mikkola provides evidence to show that the size dimorphism of the Great Gray Owl has an important biological basis. In brief, "the more substantial size of

the female compared with the male, among other things, makes possible the occupation of different ecological niches by the sexes . . . The relatively great body size of the female is important for thermoregulation during the incubation period, and the relatively small size of the male is important for agility during hunting."

Detailed analyses of occurrences of the Great Gray Owl in Norway, Sweden, Finland, Denmark, Poland, Romania, and the European part of the Soviet Union are presented. In Finland, for example, around 1900 and 1930 the Great Gray Owl was common as a breeding bird only north of the Arctic Circle. After 1938-39, the Great Gray Owl was missing in Finland (as well as in Sweden and Norway) almost completely for 15 years. In the forties eight nests were found in southern Finland. "But what happened to all the others, who had been breeding numerously in Lappland during the thirties?" The author concludes that they migrated southward to Karelian (a province of Finland). During that period one ornithologist received "about 300 killed" Great Gray Owls from that province. From 1955 to 1977 nests were found in all the provinces of Finland up to the tree limit. The focal point of the population lay in the central part of the country. "As in Sweden, the discoveries of nests during the last years have become more numerous than ever before . . . The increase may have a connection with the climatic conditions and their long-range changes. The increase in Great Gray Owls may also be connected with an increase in voles . . . According to my opinion, these owls lead a roving style of life. During the search for food they wander within the zone of the coniferous forest from the east to the west, likewise as from north to south. The greatest invasions into Northern Europe always occur when vole populations . . . have reached a low level. During these periods the Great Gray Owls may spread into southern Sweden and southern Finland. Should they encounter sufficient quantities of voles for food, they will remain in Finland and Sweden for breeding. As soon as the voles become more rare, the owls will withdraw again towards the east or the north."

I was surprised to find that Great Gray Owls have been reported nesting in the shallow, almost flat tops of stumps at least 21 times in Finland alone. Of 168 Finnish nests (1890-1977) 12% were on tree stumps. The stumps had a height between 0.7 and 5.0 metres. (Great Gray Owls have also been recorded nesting on the ground and on the thatched roof of a barn —both shown in photos). There is an intriguing photo of a female incubating on a stump with a small boy watching her from just a few feet away and at eye-level. Mikkola gives some evidence that certain individual owls actually prefer stumps to the more commonly used old raptor nests. In one case he states that the "ideal nesting stump may have influenced the choice of habitat." He hypothesizes that some Great Gray Owls have a natural preference for nesting on stumps rather than in old nests. "Thereby the natural heterogeneity of a population is being maintained, which may be essential for the long road of evolution."

"On account of his plumage the Great Gray Owl is very well adjusted to a cold climate, also already the juveniles. It is known that strong sunshine often causes the young ones to leave the nest when they are still young and completely unable to fly. During the nesting on a flat tree stump instead of on a hawk's nest, they are evidently better protected from excessive sunshine; it is also easier to jump down from the stump. Therefore the nesting on stumps should be more frequent in warm spring seasons, since the owls, in colder springtime seasons, also could move into the higher hawk eyries. In southern Finland, the spring of 1972 was very warm, and indeed, all four of the nests that were found in my southern region of study . . . were situated on stumps, which speaks for my hypothesis!"

This excellent and informative book concludes with two important topics: "Economic Importance" and "Protective Measures." Both sections are well done, and if there were space I would prefer to quote them in full, The following, from the latter section, will have to suffice:

"Without doubt, the threat by man is the main factor in the endangering of the population of this species. Although animal enemies and illnesses play a part as well, this owl is not seriously endangered by these factors. With his natural mortality, the Great Gray Owl has 'lived' through long periods of time; the shooting must be stopped."

"At present the Great Gray Owl is protected by law in his entire breeding area; in spite of this, the species is still being persecuted by hunters, at least in northern Sweden, Finland and Canada . . . The present situation in the U.S.S.R., in this respect, is not known. Much more should be done to make it clear to the public that these owls are rare, beneficial and protected by law."

"Besides the efforts of building artificial nests, all the ornithologists dedicated to owls should do their utmost to organize the effective protection of known nesting sites and biotypes. Often one can direct the destruction of lebensraum by modern forestry, traffic and building (including summer cottages in Finland) in such a way that it will not necessarily lead to the destruction of the nesting sites of the Great Gray Owl."

"When increasing tourism and recreational pastimes and the activities connected with them in nature

are not being planned specifically, they can also have locally harmful effects on the Great Gray Owls during the incubation and brooding period."

"He who wants to work for the protection of owls should also think about the fact that increasing interest in nature photography and bird watching can also mean disaster for the broods of these birds."

I think that Heimo Mikkola, in addition to providing us with an enormous amount of good solid information — and some provocative insights into owl biology and ecology — has ended his book on just the right note.

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BOTANY

The Flora of New England: a manual for the identification of all vascular plants including ferns and fern allies growing without cultivation in New England

By Frank Conkling Seymour. 1982. Second Edition. Phytologia Memoirs 5. Moldenke. (Available from author, 264 Hixville Road, North Dartmouth, Massachusetts 02747). xvii + 611 pp. U.S. $20.00+ U.S. $3.50 postage and handling.

For residents of New England and adjacent areas, this is a useful book. There are keys to families, genera, species and forms, habitat information, and most important, locations in the various states where the taxa have been found.

This second edition is an exact reproduction of the 1969 edition which was offset from typescript, with the substitution of line drawings for the rather gray photographs and the addition of ten pages of "New notes and additions and corrections" and three pages of new illustrations. Double asterisks in the margins indicate where these notes should be consulted, and double black dots show what new species have been illustrated.

The soft cover and perfect binding of the new issue are a poor substitute for the hard cover and hand sewing of the first edition which was printed in Japan.

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Moss Flora of the Maritime Provinces

By Robert R. Ireland. 1982. National Museums of Canada, Ottawa. Publications in Botany No. 13. 738 pp., illus. $20.

One always agrees to reviewing a book one hasn't seen with a certain amount of trepidation for fear of having to be critical of a colleague. But five minutes of use of Ireland's treatise soon erased all my fears. The book is one a taxonomist dreams of writing but seldom succeeds because of budget and time restraints.

Moss Flora of the Maritime Provinces combines the benefits of a generous budget and Ireland's sensitivity to the needs of both novice and professional to produce a truly excellent book at a very reasonable price.

For the beginner, excellent drawings and discussion of the life cycle of a moss begin the text, followed by collection and herbarium techniques. Methods for sectioning, staining, and mounting are especially lucid.

The end of the book is set up for rapid access by the use of heavy brown paper instead of white. Here a glossary, including plurals, refers to the excellent set of illustrations which follow. These illustrations are arranged by structure; thus they are sorted by such groupings as branch types, leaf shapes, margins, paraphyllia, *Sphagnum* structures, reproductive structures and arrangement, capsules, and peristomes. Finally, the index is purely taxonomic.

Sandwiched between these two sections are 667 pages of keys, descriptions, illustrations, and excluded taxa.

One is first aware of the author's concern for expediency on the part of the user in the key, where multiple access is possible due to use of headings. Therefore, once one has decided a moss is acrocarpous with broad leaves and papillose cells, one can quickly skip through section headings to that group, thus avoiding the small, unique groups at the beginning of the key entirely.

The next surprise is that many characters used in the key are new (compared to those used in other

floras) and they work. I found that in determining ten mosses, I made no wrong choices based on misinterpretation of the key. Difficult taxa in other keys seemed to be easy in this one.

A few weak points exist in the keys. *Fontinalis* and *Hygrohypnum* must be reached by a choice of submerged or on rocks protruding from water (vs. usually not aquatic or semi-aquatic). *Fontinalis* can occur on wood and *Hygrohypnum* can grow on damp rock cliffs, whereas *Hypnum* (which must be chosen as not semi-aquatic) can grow in very wet places (cf. *Hypnum lindbergii*).

Other problems occur in the exclusive use of capsule characters. For example, *Pleuridium* must be separated from 18 other genera on the basis of its immersed capsule. If you have no capsule, you cannot pass that couplet to go on to such easily diagnosed genera as *Tortella, Paraleucobryum,* or *Bartramia* — genera that are often sterile and could easily be separated. If one eliminates *Pleuridium,* size is the next choice, and the character of small size could easily have been added to *Pleuridium,* making determinations much easier for those users unfamiliar with *Pleuridium*.

Page numbers provided after the generic name in the key are again great time savers to the user.

Ireland's choice of nomenclature splits genera for such groups as *Mnium* into Koponen's genera and retention of *Hygroamblystegium* and *Leptodictyum* as separate from *Amblystegium*, but retains *Schistidium* in *Grimmia.* It is interesting that *Grimmia alpicola* var. *rivularis* has been elevated to a species.

Finally, the text has the sort of organization everyone dreams of. Each genus is described by sections set off in bold face: habit, colour, stems, (often including rhizoid descriptions), leaves, leaf margins, costae, leaf cells, asexual reproductive bodies, sex, calyptrae, capsules, setae, annuli, opercula, peristomes, and spores. Species descriptions are brief, including only those characters pertinent to separation from other species in the genus. Each species is described by habitat, maritime distribution, range, and chromosome number.

Another bonus is a full-page illustration for each species with the same organization on almost every page. Thus one finds the alar region illustrated in the lower right corner and one can flip through pages easily to look for the illustration that matches an unusual specimen.

One disappointing aspect is the total lack of family descriptions. This perhaps is a wise choice where many family concepts are unstable or ill-defined, but for those well-defined families, an understanding of families is very helpful.

The book seems to be on good quality paper and the printing and illustrations are clear. The binding also seems strong, but unfortunately the cloth on mine was already torn in shipment. Hopefully the book itself will last through the long span I predict for the scientific usefulness of the text.

I can give only high praise for this very excellent book. I believe it is the most thorough and most easily used flora I have seen. I believe its excellent quality and ease of use, coupled with its affordable price, will make a major and very important contribution to encouraging students and amateurs to explore the field of bryology.

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A Flora of Waterton Lakes National Park

By Job Kuijt. The University of Alberta Press, Edmonton. xxiv + 684 pp., illus. $21.00.

The long-awaited, comprehensive treatment of the exceptionally diverse flora of Waterton Lakes National Park covers over half of the species known in Alberta and serves as an important reference for much of the province and for much of the cordilleran region of western Canada.

The text begins with an introduction that includes an adequate biophysical description, a skimpy floristic/vegetation analysis and a poor discussion of previous botanical studies (that would have us believe that only A. J. Breitung (who conducted important work in the Park in the 1950's) and the author have collected in Waterton). The family key that follows would work reasonably well were it not for the frequent use of the minimally-useful phrase "Not the above combination of characters" in the contrasting half of couplets.

The species treatments are much more successful, however, beginning with technical descriptions that consciously avoid technical jargon and yet maintain their utility. A brief (and usually satisfactory) summary of habitat(s) and status in the Park (and sometimes in Alberta) follows. Taxonomic discussions (including subspecific divisions, nomenclatural opinions and/or specific problems) are included where the author considers such to be necessary. Virtually every

species is illustrated by usually effective line drawings prepared by the author. The sedges and most of the grasses, however, are not well served by these drawings which are too imprecise for the exacting requirements of illustrations for perigynia, achenes, etc.

A significant failing of this book is the alphabetical ordering of families *without* accompanying page headings. Thus the reader must rely on the index and/or hope to recognize generic affinities when searching for a particular species description — a cumbersome arrangement at best. Further to that, few species are discussed in the broader context of the cordilleran region and/or the province. The most serious failing, however, concerns the literature references — or rather, the lack of them. It is not difficult to find statements and facts that are taken directly from the published literature that are uncredited. We are forced to accept or reject statements in the text without any indication of their sources and reliability. This is particularly disturbing when the text disagrees with well-established and well-founded arrangements — such as with *Cirsium* where Kuijt is — quite simply — wrong (see R. J. Moore and C. Frankton. 1974. *The Thistles of Canada.* Agriculture Canada, Ottawa). It is incumbent on the author to provide an indication of his sources and/or a rationale for such decisions, as well as offering due credit to the work of others. Such a practice also puts the thoroughness of the literature search in some question, as does the omission of well-documented species (such as *Pellaea* [*occidentalis*] *pumila*) from the list of possible additions (page xvii).

The book is nicely produced. It has a very attractive cover, is printed on good quality paper and utilizes a clean, easily-readable type-face. The lay-out is effective and economical and a small selection of colour photographs of common and/or typical species enlivens the text. The glue and stitch binding is flexible and appears to be very durable.

This volume contains a wealth of information on the vascular flora of southwestern Alberta and will quickly become the 'bible' for mountain botanists in that province. Its overall usefulness is great and it is produced in an attractive and affordable package. For anyone interested in Canadian mountain flora, this is a 'must'. The organizational and documentational problems aside, Kuijt has done western Canadian botany — and botanists — a real service with this effort.

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ENVIRONMENT

Biological Monitoring in Water Pollution

By John Cairns Jr. and collaborators. 1982. Pergamon Press, Oxford. 130 pp., illus. U.S. $34.50.

In this book, John Cairns Jr. and collaborators illustrate the utility, and indeed the need of measuring biological response in concert with routine physical and chemical measurements to manage wastewaters released into aquatic environments. The authors review the literature on various aspects of biological monitoring in pollution assessment, and argue the need for much greater development in this field.

The first chapter reviews the use of biological early warning systems. This approach to environmental management — once used by miners who placed canaries underground to detect poisonous gases — is described as a rapidly evolving field. Numerous techniques of detecting toxicity in waste streams before discharge are described. These early warning systems are engineered into the waste treatment system, and provide continuous monitoring whereby an alarm is triggered when biological activity such as swimming behaviour or respiration in the test organisms (usually bacteria or fish) deviates significantly from a predetermined norm due to the presence of a toxicant. Existing early warning systems are few and a large proportion are fraught with problems in routine use. The obvious advantage of this approach is that toxicity problems are recognized and may be corrected before wastewater discharge to the environment.

Chapters IIA and III (oddly, there is no chapter IIB) review a range of approaches for biomonitoring in receiving waters. The need to monitor not only structural parameters such as species composition or diversity, but also functional parameters such as rate of colonization or respiration is discussed at length. The importance of measuring community level variables is stressed, and toxicity testing with experimental microcosms is espoused. Only by such approaches, the authors argue, can the high uncertainty surrounding the interpretation of biological survey data from degraded environments be significantly reduced.

In chapter IV, toxicity testing is examined as a regulatory tool to assess the acute and chronic effects of pollutants. The authors highlight the inadequacies of using the widely practised laboratory tests based on

single species and single toxicants to predict impacts in the ecologically complex, open environment that is often already contaminated from other sources. Because of those inadequacies, the adoption of more environmentally meaningful, multispecies and ecosystem level toxicity tests is suggested.

Chapter V describes preference — avoidance testing in evaluating biological response to effluents. Such tests have been used in the past primarily to monitor response to thermal gradients. In nature, avoidance of a polluted condition may be vital; however, such behaviour might also preclude normal migratory movements (e.g. spawning), to the obvious detriment of the population.

In the concluding section (Chapter VI) the need for ecologists to improve their ability to predict impacts is discussed. Particular emphasis is placed on multispecies and system level tests. Improved predictability would permit prudent watershed management through an improved understanding of assimilative capacity and of realizable benefits in designing rehabilitation programs for damaged ecosystems.

Upon first opening this new book, I was struck with a feeling of déjà vu — the book is a collection of reprints of papers published from 1980 to 1982 in the journal Water Research (also by Pergamon Press). This was done to provide an earlier release of the material and to avoid extra cost. The pages bear the same page numbers as assigned by the journal, and thus page numbering between chapters is not sequential. Fortunately, a table of contents showing page numbers for each part, and dividers of heavy weight paper assist the reader in locating positions in the book. Other features added to convert this reprint collection into a book include title pages, a forward, a preface, an index, and a sturdy cover.

In addition to its peculiar format, the book suffers from some organizational inconsistencies. The authors acknowledge most of these in the preface. The level of detail and length from chapter to chapter is inconsistent. A supplement to Chapter I is presented after the first chapter in a very awkward attempt to update the literature without revising the original review. Chapter V on preference and avoidance is in stark contrast to the other chapters — it dwells on recounting a large number of specific study findings rather than demonstrating the industrial and regulatory utility of these behavioural responses in environmental management. For example, this chapter presents an overwhelming and unnecessary eight-page table listing temperature preference data for fish.

In all, I feel this book is a good attempt to promote continued evolution of biological monitoring as an important tool in the wise management of aquatic resources. I recommend the book to water pollution control engineers, applied aquatic ecologists, and environmental managers; it may be less attractive to the pure ecologist and naturalist.

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The Natural Environment of Newfoundland, Past and Present

Edited by A. G. Macpherson and J. Brown Macpherson. 1981. Memorial University of Newfoundland, St. John's. xviii + 265 pp., illus. $17.50.

By virtue of its isolated seaward position midway on the Atlantic Coast of Canada, the island of Newfoundland and adjacent Labrador, contain an unusual geological history which subsequently has shaped its unique physical, biotic, and human character. These attributes, which typify and give Newfoundland its identity, are re-emphasized in the papers contained in this volume.

Physical geographers at Memorial University have amassed their various fields of expertise in eight papers which summarize all dimensions of the physical environment of Newfoundland, including the lithosphere (Precambrian geology to the immediate Postglacial), the hydrosphere (both the surrounding offshore sea and terrestrial freshwater systems), and the atmosphere (climate). Adding to this, Postglacial vegetation history and climatic change, biota, man, and adventive weeds, one has *The Natural Environment of Newfoundland, Past and Present.*

This book will be an invaluable reference, teaching guide, and information source for both professionals seeking technical data, and rainy day novelists simply interested in Newfoundland. For example, the detailed climatic maps for Newfoundland are precisely the type of information only too often sought for other regions of Canada. I found the accounts of some early Newfoundland explorers amusing, such as John Rut's description of the coast as: "all wildernesse and mountaines and woods, and no natural ground but all mosse", and Whitbourne's record of "squides, a rare kinde of fish, at his mouth squirting mattere forth

like Inke". Scientists, resource managers, and naturalists interested in the Atlantic Coast should certainly see this book.

Apart from a printing error on page 188, and a personal preference to present chapters dealing with abiotic aspects first, followed by those dealing with biotic aspects, rather than mixing them, I see little worthy of criticism.

In view of inflated book prices these days, the high quality type-setting, clear and concise graphics, heavy paper stock, and 265 pages, I find it is a real bargain at $17.50.

I applaud the editors and their contributors, and give the book high marks for a superb and useful product which should set a precedent for other Canadian regions. Since as the editors state in the Preface, that this book is intended to be a companion to an earlier volume, which presumably focused on archaeologic and cultural aspects of Newfoundland, let me encourage the Biology Department at Memorial University to provide a third companion volume on the biotic resources of Newfoundland.

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Conservation Biology: An Evolutionary — Ecological Perspective

Edited by M. E. Soulé and B. A. Wilcox. 1980. Sinauer, Sunderland, Massachusetts. xv + 395 pp., illus. U.S. $14.95.

Conservation Biology is a useful volume of papers devoted primarily to the conservation of species and ecosystems. Nineteen chapters are grouped into four parts. Part one consists of five chapters which seek to illustrate ecological principles of conservation in the tropics. Mammals, birds, and tropical forest ecosystems are featured in illustrating the complexity and values rapidly being depleted.

Part two examines different aspects of population structure and dynamics on ecological "islands", or insular areas of habitat. This concept is well known among biologists and resource managers, and the five chapters here provide a thorough and excellent review of the subject. Part three explores the issues of the propagation and reintroduction of species from captivity. The importance of zoo populations is discussed in various contexts. Genetic and behavioural problems with captive populations are well reviewed. Part four consists of four chapters which offer a frank and not very optimistic overview of the consequences to species (including ours) and ecosystems of continual conventional economic and cultural exploitation. These discussions are not restricted to North America, but also touch on moist and arid tropical settings.

A summary of this length cannot delve into specifics. This is rather a disservice to a comprehensive, informative, and well edited treatment of the subject. The book is unique in that its focus is narrow, i.e. the conservation of species and ecosystems, yet it approaches this focus with a very wide perspective. I recommend this book very highly.

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NEW TITLES

Zoology

Alaska bear tales. 1983. By Larry Kaniut. Alaska Northwest, Anchorage. 318 pp. U.S. $11.95 plus U.S. $1 postage.

An analysis of toads of the *Bufo americanus* group in a contact zone in central northern North America. 1983. By Francis R. Cook. Publications in Natural Sciences, no. 3. National Museum of Natural Sciences, Ottawa. 89 pp., illus. Free.

Avian biology, volume VII. 1983. Edited by Donald S. Farner, James R. King, and Kenneth C. Parks. Academic Press, New York. 576 pp. U.S. $69.95.

†**Behavior of fledgling peregrines.** 1983. By Steve K. Sherrod. Peregrine Fund, Ithaca, New York. xi + 202 pp., illus. U.S. $10.

The biology of crustacea, volume 7: behavior and ecology. 1983. Edited by F. John and Winona B. Vernberg. Academic Press, New York. 352 pp. U.S. $45.

The biology of crustacea, volume 8: environmental adaptations. 1983. Edited by F. John and Winona B. Vernberg. Academic Press, New York. 400 pp. U.S. $49.50.

Biology of desert invertebrates. 1981. By Clifford S. Crawford. Springer-Verlag, New York. xvi + 314 pp., illus. U.S. $39.30.

The biology of lampreys, volumes 4a and 4b. 1983. Edited by M. W. Hardisty and J. C. Potter. Academic Press, New York. 320 pp. and 288 pp. U.S. $60 and U.S. $53.

†**Bird conservation, number 1.** 1983. Edited by Stanley A. Temple. University of Wisconsin Press, Madison. vii + 148 pp. U.S. $12.95.

The birds of Peterborough County: an annotated list. 1983. By Doug Sadler. Peterborough Field Naturalists, Peterborough. 170 pp., illus, $7.50 plus postage.

Birds of tropical America. 1983. By Alexander F. Skutch. University of Texas Press, Austin. xii + 305 pp., illus. U.S. $29.95.

*****Breeding birds of the Baraboo Hills, Wisconsin: their history, distribution, and ecology.** 1982(1983). By M. J. Mossman and K. I. Lange. Department of Natural Resources, Madison. 197 pp., illus. U.S. $6 plus postage ($.75 for first copy and $.25 per additional copy).

Cephalopod life cycles, volume 1: species accounts. 1983. Edited by P. R. Boyle. Academic Press, New York. c440 pp. no price given.

Encyclopedia of aviculture: keeping and breeding birds. 1983. By Richard Mark Martin. Arco, New York. xii + 228 pp., illus. U.S. $14.95.

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Cover: Eastern Spiny Softshell, *Trionyx spiniferus spiniferus*, photographed by Len Simser, Royal Botanical Gardens, and Martyn Obbard, see note by Obbard and Down pp. 254–255.

The Canadian Field-Naturalist

Volume 98, Number 2 April-June 1984

Characteristics of Sites Occupied by Wild Lily-of-the-Valley, *Maianthemum canadense*, on Hill Island, Ontario

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Crowder, A. A., and Gregory J. Taylor. 1984. Characteristics of sites occupied by Wild Lily-of-the-Valley, *Maianthemum canadense*, on Hill Island, Ontario. Canadian Field-Naturalist 98(2): 151–158.

One hundred and thirteen sites on an island in the Thousand Islands region of the St. Lawrence River were studied to determine the environmental factors active in controlling the local distribution of *Maianthemum canadense* var. *canadense* (Wild or False Lily-of-the-Valley). The plant occurred most frequently in areas with moderate shade and evaporation and with a low cover of graminoid plants. Standing crop was negatively correlated with levels of evaporation, and positively correlated with penetration of light through the tree canopy and soil phosphorus. Analysis of interspecific associations indicated a positive correlation between the presence of *Maianthemum canadense* and the following species: *Tsuga canadensis, Acer saccharum, Carya ovata, Solidago caesia,* and *Pteridium aquilinum.* A negative correlation was detected with *Rumex acetosella* and *Deschampsia caespitosa.*

Key Words: Autecology, *Maianthemum canadense*, Wild or False Lily-of-the-Valley, Ontario, environmental factors, interspecific association, distribution.

The distribution of a plant species is limited by external factors which include soil and climate and by its reproductive strategy and biotic interactions. The 'realized niche' of a species (Hutchinson 1958), the 'space' in which its individuals live, may be delimited by one circumscribing factor such as grazing pressure, or by several interrelated environmental factors.

In the Thousand Islands region of the St. Lawrence River the distribution of *Maianthemum canadense* is patchy. The region is situated at the heart of the North American distribution of the plant, hence it would not be expected that macroclimatic factors would be responsible for this pattern. At the same time, however, casual observations suggest that plant–soil relationships also are not important in producing pattern. While growth from rhizomes would explain small scale clumping, it cannot account for the larger scale patchiness that is evident. Therefore one might hypothesize that biotic interactions are of primary importance in developing pattern within the region.

This paper reports on the influence of a number of physical and biotic factors on the local distribution of *Maianthemum canadense* within the Thousand Islands region. While it is not possible to determine the mechanisms controlling distribution with field work such as presented here, it is possible to suggest which factors may be most active in determining local distribution. Further experimental testing is required to determine causal relationships.

The Plant

Maianthemum canadense var. *canadense* (Liliaceae) is a small herbaceous perennial with creeping rhizomes and is a rhizome geophyte. In Ontario, Sparling (1964) showed that *Maianthemum canadense* attains maximal leaf biomass and flowers in May, then maintains this biomass throughout the summer. Vegetative reproduction is important (Silva et al. 1982), and Whitford (1949) assumed that large clumps, which may be up to 6 m in diameter, are clones. Sobey and Barkhouse (1977) found the yearly growth increment of rhizomes to be 15–30 cm/yr, hence if a large clump had a single seed as its origin it could be 30 to 60 years old. Two varieties of the plant are known to occur in eastern Ontario (Beschel et al. 1970; Kawano et al, 1967, 1968; Ingram 1966) but all individuals encountered within the study area were *Maianthemum canadense* var. *canadense.*

The Study Area

The study area is located at the southern tip of Hill Island, Leeds County, Ontario. Hill Island is part of

the Frontenac Axis, being primarily composed of granite, but partly overlain by Ordovician sandstone and a patchy cover of sand and gravel (Wynne-Edwards 1962). Both granite and sandstone outcrop in the study area. Local climate is moderated by the presence of Lake Ontario, so that the number of growing days is comparable to that occurring south of London, Ontario. The average continuous frost-free period is between 140 and 150 days and the duration of snow cover is highly variable (Hirvonen and Woods 1978). The effect of aspect and a steep microrelief is to create marked differences in microclimate, with southwest facing slopes being dry and warm while slopes with a northeasterly aspect are cooler and wetter. The possible influence of such microclimatic gradients on the distribution of tree species further west on the Frontenac Axis was studied by Jafri (1965). Species common to both Jafri's study and this study include *Tsuga canadensis* (Eastern Hemlock), *Pinus strobus* (Eastern White Pine), *Acer saccharum* (Sugar Maple), *Quercus alba* (White Oak), and *Carya ovata* (Shagbark Hickory).

The parent materials of Hill Island include deep glacio-fluvial and glacio-lacustrine sediments, some alluvium, and organic deposits. However, in the study area soils are exclusively shallow with numerous bedrock outcrops. Plant cover is discontinuous because of patches of rock. Soil texture is predominantly sandy.

The communities occurring in the study area closely resemble those found elsewhere in the region by Hirvonen and Woods (1978). Occurring on or bordering the most exposed rocky outcrops, moss and lichen communities dominate with small patches of soil being colonized by drought-tolerant plants such as *Rumex acetosella* (Sheep Sorrel). Where soil is sufficient to support more extensive growth, well-drained southeasterly aspects are characterized by a sparse incidence of *Pinus strobus, Pinus rigida* (Pitch Pine), *Juniperus virginiana* (Eastern Red Cedar), *Quercus borealis* (Red Oak), and a dense mat of *Deschampsia caespitosa* (Tufted Hairgrass).

In less arid areas a mixed woodland community characterized by *Pinus strobus, Quercus borealis,* and *Acer rubrum* (Red Maple) can be found. This community generally has a sparse canopy, thereby allowing species such as *Solidago caesia* (Blue-Stemmed Goldenrod), a number of graminoid species, and some shrubs including *Prunus serotina* (Black Cherry), *P. virginiana* (Choke Cherry) and *Amelanchier arborea* (Juneberry) to occur. These communities may also support seedlings of *Carya ovata* and *Acer saccharum.* More moist depressions often harbour luxuriant growth of *Pteridium aquilinum* (Bracken Fern).

Moist sites occurring in large depressions and on north and easterly exposures are characterized by one of two communities: a predominantly coniferous forest consisting of *Pinus strobus* and *Tsuga canadensis,* with lesser occurrences of *Acer rubrum, Quercus borealis,* and sparse herbs; or alternatively a deciduous forest characterized by a large number of species, including *Acer rubrum, Acer saccharum, Quercus borealis, Carya ovata, Fraxinus americana* (White Ash), and *Tilia americana* (Basswood). Here the understory is shaded, and supports a lush growth of *Parthenocissus inserta* (Virginia Creeper).

Materials and Methods

Because of numerous cliffs and rock outcrops, placing random sampling plots on a grid proved impossible. Accordingly a trail following, but not restricted to, major pockets of soil was blazed before the plants emerged in the spring. One hundred and thirteen points were marked at regularly spaced intervals along the trail and, when growth commenced, circular plots were established. If individuals or clones of *Maianthemum canadense* occurred within 5 m of the marked point a plot was established to include the closest individual or clone. Otherwise the plot was established at the point itself. Using this technique it was possible to obtain a sufficiently large number of sites (72) in which the plant occurred. The size of plots varied for the various parameters measured at each site. The 113 sites were scattered within an area of 6.5 ha.

Throughout eight weeks of the 1976 summer season, four Piché atmometers were run, two on a protected northeastern slope and two on an exposed southwestern slope. Evaporation values from the two atmometers for each slope were averaged to give two standard curves running for the eight weeks. The northeast curve was arbitrarily assigned a relative evaporation value of 10.0 while the southwest curve was assigned a relative evaporation value of 20.0. Evaporation at each of the 113 sites was measured with atmometers for at least one week and compared to the standard points for that week. Relative evaporation values for each site were then assigned, based upon a comparison with the two standards. Values ranged from 3.8 to 30.2. This use of standard atmometers is comparable to the method used by Wolfe et al. (1949).

Light penetrating through the forest canopy was determined as total irradiance at ground level, reported as percentage intensity of full sunlight reaching ground level under cloudless conditions in mid August. This method ignores all subtlety in measuring light intensity (Evans 1966; Sparling 1964) but allowed a rapid comparison of the effects of the tree canopy to be made.

Bedrock was identified at the nearest outcrop. The

transition from granite to sandstone was sharply marked, so no errors are thought to have been made. Soil depth was measured down to 20 cm; points with deeper soil being recorded as > 20 cm. Soil samples of a standard volume were collected from the top 20 cm of soil after removal of the litter. This zone included all the rooting depth of the plant.

Samples were analyzed at the Ontario Soil Testing Laboratory, University of Guelph, for pH, K, P, Mg, Ca, and texture. All samples were dried at 90° C and sieved through 2 mm mesh. Soil pH was determined by the addition of sufficient distilled water to create a soil paste 20 minutes prior to measurement (Allen et al. 1974; Black et al. 1965). Ammonium acetate (pH 7.0) extractable K, Mg, and Ca were prepared with a 1:10 soil extractant ratio, agitated for 15 minutes and filtered through Whatman 42 filter paper. Determination was accomplished by atomic absorption spectrophotometry. Phosphorus was extracted with sodium bicarbonate (0.5 M buffered at a pH of 8.5 in NaOH) with a soil extractant ratio of 1:20, agitated for 30 minutes, and filtered through Whatman 42 filter paper. Determination was accomplished with a Techman Autoanalyzer.

All woody species within a radius of 5 m and all herbs within a radius of 1 m of each sampling point were recorded. Cover of graminoid plants was estimated as a percentage within the 1 m radius. Graminoid plants included non-flowering grasses and young sedges. Aside from *Maianthemum canadense* other herbs did not produce a continuous dense cover.

After cessation of growth, in mid-September, all shoots of *Maianthemum canadense* occurring in an area of 3.5 m^2 centred on each sampling point were harvested. All shoots rising above litter were counted and cut off just above the over-wintering bud. Standing crop biomass was then determined after drying to constant weight at 90° C.

The full data set (n = 113) was divided into two subsets, M + for those sites where *Maianthemum canadense* was present (n = 72) and M – where it was absent (n = 41). The T-test was utilized to determine if the M + and M – subsets were clustered on different portions of each of the full environmental gradients encountered (testing for the significance of the difference in the two means, M + and M –, for each environmental parameter). Possible relationships between standing crop and the continuous environmental factors were examined by regression analysis and association between the presence of *Maianthemum canadense* and non-continuous variables (presence or absence of other species, soil texture and bedrock) was determined by the chi-square test.

Results

Individuals of *Maianthemum canadense* were found growing in the full environmental gradient of relative evaporation as represented by the M + and M – sites (Figure 1A), but there was a concentration of plants in the more humid sites. The mean evaporation value for M + sites was significantly lower ($p < 0.01$) than that for the M – sites. *Maianthemum canadense* did not occur in the most densely shaded sites, but occupied the remainder of the environmental gradient including fully open sites (Figure 1B). Most of the sites were clustered in the lightly shaded portion of the gradient and the mean light penetration estimate for M + sites was significantly lower ($p < 0.01$) than for M – sites. While *Maianthemum canadense* survived where the cover from graminoid plants was 100% it tended to cluster at the other end of the gradient where cover of grasses and/or sedges was least (Figure 1C). The mean value of graminoid cover for M + sites was significantly lower ($p < 0.01$) than that for M – sites.

Soil depth appeared to be unimportant in determining the presence of *Maianthemum canadense*. The plant occurred in any depth of soil, provided some soil was present. More M + sites were found on sandstone than would be expected randomly ($p < 0.01$), but this cannot be attributed directly to the type of bedrock. It was found that sandstone sites generally showed low evaporation and moderate shading which are also the preferred portions of these gradients. This relationship may result from the fact that all sandstone sites were located on the more protected northeast exposure. It is, however, difficult to be sure that the sandstone itself, due to its pervious nature, does not produce a more moist, and hence more suitable, growing site. Soil texture and pH were not associated with the presence of the plant.

The mean soil concentration of Mg, Ca, P, and K at M + sites was not significantly different from that for M – sites ($p > 0.15$, Table 1). The gradients for Ca and Mg were fully exploited by the plant, indicating that the plant did not select subsections of the full gradient encountered in the study stie. The frequency polygon for phosphorus (Figure 1D) shows a slight clustering of M + sites in a restricted portion of the gradient, but this did not result in a significant difference in the M + and M – means ($p = 0.36$).

Table 1 also gives the mean, standard deviation, and range of *Maianthemum canadense* standing crop biomass for M + sites. Simple regression analysis of the M + data (continuous variables only) demonstrated that only the relative evaporation was significantly and negatively correlated with biomass ($p < 0.01$). As several scatter diagrams indicated a possible logarithmic relationship between the dependent and independent variables, simple regression analyses were performed with biomass as the dependent variable versus the natural log of all the

TABLE 1. Mean above-ground biomass of *Maianthemum canadense* at M + sites and mean concentrations and T-test significance levels for the difference in mean concentrations of available soil nutrients in sites with (M +) and without (M –) *Maianthemum canadense* on Hill Island, Ontario. St. crop = standing crop. Plot area = 3.5 m^2.

	Maianthemum canadense Present (n = 72)		*Maianthemum canadense* Absent (n =41)		T-test Significance Level
Variable	mean ± SD	Range	mean ± SD	Range	
M. canadense st. crop (g/plot)	2.4 ± 2.0	0.05 – 11.05	—	—	—
Potassium (ug/g)	105 ± 45	40 – 260	104 ± 40	36 – 200	0.91
Phosphorus (ug/g)	60 ± 28	15 – 120	54 ± 27	13 – 120	0.36
Calcium (ug/g)	384 ± 263	125 – 1700	486 ± 404	125 – 1900	0.15
Magnesium (ug/g)	58 ± 34	15 – 156	64 ± 46	12 – 200	0.45

independent variables (except pH). In these analyses, the natural log values of the relative evaporation values were negatively correlated, and the natural log values of the light penetration were positively correlated with biomass ($p < 0.04$ and $p < 0.02$ respectively). The other factors measured were not significantly related to biomass ($p > 0.211$).

Multiple regression analysis of the untransformed data demonstrated that the light penetration estimate was the best predictor of biomass. The residuals from this regression were best explained by soil potassium followed by the relative evaporation value, percent graminoid cover, and the remaining soil characteristics. Only the inclusion of the first variable in the multiple regression equation was significant at the 5% level and only a small portion of the total variance was explained ($R^2 = 0.13$ for the significant variable, $R^2 = 0.23$ for all remaining variables) and only a small portion of the total variance was explained.

Multiple regression analysis was repeated using the natural log of each independent variable (except pH). Relative evaporation proved to be the best predictor of biomass, while percent light penetration and soil phosphorus explained a significant portion of the residuals ($p < 0.05$). Thirty eight per cent of the total variation was explained ($R^2 = 0.38$) by the first three variables, and 48% ($R^2 = 0.48$) after inclusion of the remaining five variables in the analysis.

Sixty species of trees (as seedlings), shrubs, herbs, ferns, and mosses were found within the smaller plots and 19 species of trees occurred within the larger plots. Table 2 lists the species present in 10 or more plots together with their frequency of occurrence and an indication of their association with the presence or absence of *Maianthemum canadense*. Less common herbs included the spring-flowering plants such as *Trillium grandiflorum* (White Trillium), *Polygonatum pubescens* (Solomon's Seal), and *Smilacina racemosa* (False Solomon's Seal). *Maianthemum canadense* was found to be positively associated with the trees *Tsuga canadensis, Acer saccharum,* and *Carya ovata* and with *Solidago caesia* and *Pteridium aquilinum.* It was negatively associated with *Rumex acetosella* and *Deschampsia caespitosa.*

Discussion

Of the eleven factors investigated, three were found to be significantly correlated with the presence or absence of *Maianthemum canadense* ($p < 0.01$): percent light penetrating through the forest canopy, the relative evaporation estimate, and cover by graminoid plants. Bedrock type was also associated with the presence or absence of *Maianthemum canadense*; however, its significance may have been a result of other factors. Over 80% of M + sites occurred where there was little graminoid cover, moderately low evaporation, and moderate shading. *Maianthemum canadense* also tended to occur more frequently in the middle of the soil phosphorus gradient, although it did grow throughout the full gradient of concentrations sampled.

Maianthemum canadense was not normally present in sites where graminoid cover was high, but when it did occur in such sites no significant relationship existed between standing crop biomass and graminoid cover. If the *Maianthemum canadense* – graminoid relationship were directly competitive, resulting in reduced growth of *Maianthemum canadense*, a negative correlation would be expected (Cable 1969; Bell and Nalewaja 1968; Simms and Mueller-Dombois

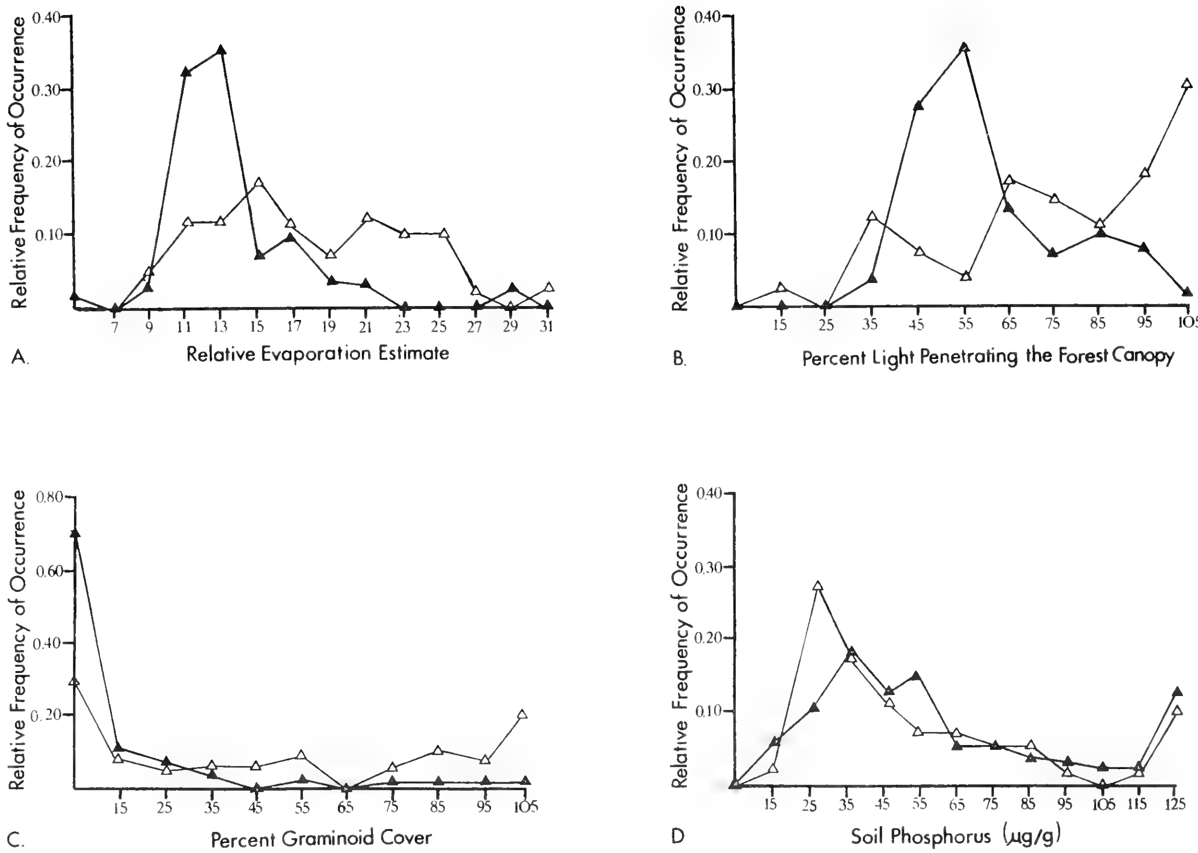

FIGURE 1. Frequency distribution of the relative evaporation estimate (1A), percent light penetrating the forest canopy (1B), percent cover by graminoid species (1C), and soil phosphorus concentrations (1D) at sites with (n = 72) and without (n = 41) *Maianthemum canadense.* Plots with solid triangles represent the relative frequency of occurrence of sites with *Maianthemum canadense* (M +), while plots with open triangles represent sites without *Maianthemum canadense* (M –). For A, B, and C, the mean for M + sites is significantly lower than the mean for M- sites ($p < 0.01$), indicating that *Maianthemum canadense* is selecting restricted portions of the environmental gradient encountered. For D, however, the M+ and M– means are not significantly different ($p = 0.36$). Note the greater range in relative frequencies indicated in C.

TABLE 2. Percent frequency of occurrence and association between *Maianthemum canadense* and plant species occurring in 10 or more of the 113 sample sites in the Hill Island study area.

Species	Common Name	Percent Occurrence	Association with *M. canadense*
Polytrichum commune	Juniper Haircap Moss	24	NS*
Pteridium aquilinum	Bracken Fern	34	++
Pinus rigida	Pitch Pine	15	NS
Pinus strobus	Eastern White Pine	39	NS
Tsuga canadensis	Eastern Hemlock	20	+
Deschampsia caespitosa	Tufted Hair Grass	35	--
Deschampsia flexuosa	Common Hair Grass	25	NS
Agrostis hyemalis	Hairgrass	12	NS
Poa compressa	Wiregrass	12	NS
Amelanchier arborea	Juneberry	11	NS
Carya ovata	Shagbark Hickory	29	+
Quercus borealis	Red Oak	62	NS
Quercus alba	White Oak	25	NS
Rumex acetosella	Sheep Sorrel	11	--
Prunus serotina	Black Cherry	43	NS
Prunus virginiana	Choke Cherry	12	NS
Acer rubrum	Red Maple	9	NS
Acer saccharum	Sugar Maple	39	++
Solidago caesia	Blue-stemmed Goldenrod	42	++

*"NS" indicates no significant association "+" or "–" indicates a positive or negative association ($p < 0.05$), and "++" or "--" indicates a positive or negative association ($p < 0.01$).

1968). Possibly measurement of both the above- and below-ground biomass could clarify this relationship, unless it is the expansion of an entire clone rather than the individual shoot biomass that is affected.

Cover of all plants present limits the amount of light reaching *Maianthemum canadense*. While M + sites occurred more frequently in areas with low light intensity (measured in August), the performance of shoots (judged by standing crop biomass) was better with high light intensity; the larger biomass per unit area was found in open sites. Silva et al. (1982) also found that the density of *Maianthemum canadense* increased with increasing irradiation and decreasing soil moisture. The explanation for this anomaly is possibly similar to that put forward for other woodland herbs such as *Impatiens parviflora* [Jewelweed] (Coombe 1966). The plant continues to increase assimilation as light intensity increases, but becomes limited at high light intensities by loss of water resulting in stomatal closure and a reduction in the supplies of carbon dioxide to the leaf. Such plants occur in open sites only if the supply of soil moisture is sufficient (Rackham 1966).

The wide habitat amplitude of *Maianthemum canadense* is shown by its positive association with the conifer, *Tsuga canadensis*, which produces deep shade throughout the season and with the deciduous tree, *Carya ovata*, which produces little shade in spring and only moderate shade in summer. Obviously these two tree species produce very different microclimatic regimes. In Massachusetts *Maianthemum canadense* is said to be common under *Pinus strobus* and scarce under hardwoods (Griffith et al. 1936). The three trees positively associated with *Maianthemum canadense* in this study were found by Jafri (1965) to occupy different habitats on the Frontenac Axis. *Acer saccharum* was common on flat ground and east slopes, *Tsuga canadensis* on north and east slopes, and *Carya ovata* on southern slopes. Individuals of *Acer saccharum* in the study area were primarily seedlings, and the positive association with this species probably indicates similar tolerance to shading. However, it appears that *Tsuga canadensis, Carya ovata,* and *Pteridium aquilinum* all create microhabitats within which tree seedlings (such as *Acer saccharum*), *Maianthemum canadense*, and *Solidago caesia* can either co-exist or compete.

The wide habitat amplitude of *Maianthemum canadense* in the Thousand Islands region is substantiated by a recent classification of regional vegetation (Hirvonen and Woods 1978). Hirvonen and Woods clustered 109 sample plots into nine groups and recorded *Maianthemum canadense* in six of them. In three groups, *Maianthemum canadense* was a characteristic species. One of these, the *Tsuga* group, repeats our positive association with *Tsuga canandensis* on a

larger scale. The positive association with *Pteridium aquilinum* in our plots was also found in the *Aralia-Carpinus* group. Finally, Hirvonen and Woods (1978) found *Acer saccharum* and *Carya ovata* to be regenerating species in two groups that included *Maianthemum canadense* as a characteristic species. This supports our findings which indicate a positive association between *Maianthemum canadense* and *Acer saccharum* seedlings.

Negative associations with *Deschampsia caespitosa* and *Rumex acetosella* are not surprising. In the region, these plants are characteristic of open, dry, rocky sites, and often of disturbed areas (Bechel 1969). They can be regarded as r-strategists while *Maianthemum canadense*, with its large clones and shade tolerance, can be regarded as a K-stategist (cf. Grime 1979). *Maianthemum canadense*, however, can be quite resilient in a disturbed situation and has been observed by the authors flourishing in an Ontario Hydro right-of-way which had been sprayed with herbicide.

It was initially hypothesized that biotic interactions might control the local distribution of *Maianthemum canadense* in this part of its range, where it is not near macro-climatic limits. Apparently, however, the microclimatic conditions of light and relative evaporation created by the microrelief and by other plants are of greater importance than direct effects such as competition or allelopathy. Supporting this conclusion, Silva et al. (1982) suggested that environmental rather than density controls were primary causes of population demography characteristics in New England populations of *Maianthemum canadense*. Solar irradiation and soil moisture were implicated as important environmental factors.

The edaphic characteristics investigated (soil, depth, texture, pH, Ca, Mg, P, and K) did not seem to play an important role in determining which sites were occupied by the plant. However, in attempting to explain the growth of *Maianthemum canadense*, soil phosphorus (natural log) did account for a significant portion of the residual variance not accounted for by the first two variables included in the regression equation ($p < 0.05$). Goodman (1969) has commented that soil phosphorus is often the most important nutrient in ecological situations; Pigott and Taylor (1964) found that soil phosphorus affected the relative performance of woodland herbs and that *Deschampsia caespitosa,* which was negatively associated with *Maianthemum canadense* in this study, did not respond to additions of phosphorus, nitrogen, or a combination of the two.

Factors not measured in this study which may affect the pattern of local distribution include the annual regime of microclimate and snow cover, the concentrations of other soil nutrients such as nitrogen, and reproductive strategy, to name a few. For example, it is known that some *Maianthemum canadense* seeds are dispersed by birds, including the ruffed grouse (Martin et al. 1951), which would tend to produce a patchy distribution. Even assuming seeds reached all suitable sites, such factors as disease, predation, and allelopathy could affect their success, or *Maianthemum canadense* seedlings may not be capable of competing with plants which have pre-empted the suitable micro-sites. However, in the Thousand Islands region, it would appear that competition for light, availability of water, levels of soil phosphorus, and possibly a competitive interaction with graminoid species may all be active in determining local distribution.

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Origins of Organochlorines Accumulated by Peregrine Falcons, *Falco peregrinus*, Breeding in Alaska and Greenland

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Differential productivity among populations of Peregrine Falcons breeding in Greenland and in arctic and interior Alaska was found to be closely associated with DDE levels in unhatched eggs and in the lipids of eggshell membranes. These regional differences in DDE levels on the breeding grounds might be explained by: 1) regional differences in exposure to DDT on the wintering grounds in South America; 2) regional differences on the breeding grounds of contamination levels in migrant prey species also wintering in South America; and 3) differences in the relative amounts of "clean" prey, including resident species, consumed on the breeding grounds prior to egglaying. These hypotheses were examined by determining both the concentrations and the concentrations relative to DDE of several organochlorine biocides and their environmental derivatives in peregrine eggs. Relatively higher levels of dieldrin in arctic Alaska and of mirex in interior Alaska, compared to DDE, indicated regional differences in exposure, either in South America, or through the consumption on the breeding grounds of migrant prey species. The general features of the "fingerprint" profile of organochlorine contaminants throughout Alaska and Greenland, however, were markedly different from the profile of the same synthetic organochlorines measured in unhatched eggs of Peregrine Falcons breeding in California, where several of the organochlorine insecticides are no longer used. Continuing examination of the relative levels of these organochlorines in peregrines and their prey might be expected to yield additional information on their origin. A trend towards decreasing levels of DDE was observed in the late 1970's, coinciding with reports of improvements in reproductive success, and with decreases in DDT use in areas of South America.

Key Words: Peregrine Falcon, *Falco peregrinus*, organochlorines, Alaska, Greenland.

Following the conference on the Peregrine Falcon (*Falco peregrinus*) in 1965 (Hickey 1969), expeditions were mounted in 1966 in Alaska and northern Canada to determine whether Peregrine Falcons breeding in those areas had experienced a population decline comparable to those which had been documented in other areas of North America and in Europe (Cade et al. 1968; Enderson and Berger 1968). Peregrine Falcons breeding on the upper Yukon River in Alaska in 1966 were present in numbers comparable to those observed in 1951. Breeding success appeared to fall within historical limits, although high levels of the DDT compound p,p'-DDE (DDE) were recorded in tissues of young and adult peregrines and in peregrine eggs (Cade et al. 1968). Similarly, observations in 1967 on the Yukon and Porcupine rivers in Alaska and in Yukon Territory indicated that both the number of known pairs and the reproductive success per pair were within normal limits, although high levels of DDE were recorded in three of four biopsy fat samples (Enderson et al. 1968).

The number of breeding pairs remained steady through 1969 on the Yukon and Colville rivers, but a downward trend in the number of young produced per breeding pair was evident (Cade et al. 1971). A further decrease in the number of young produced per pair, associated principally with an increase in the number of pairs that failed completely, was observed in 1970 (Cade et al. 1971). By 1975, the numbers of active sites on the upper Yukon and Colville were about 40 % and 60 %, respectively, below the numbers observed in the 1950's and 1960's (Fyfe et al. 1976). Only one pair, which produced only one young, was found breeding on the Tanana in 1974 compared to a historical population of 14-16 pairs (J. R. Haugh *in* Fyfe et al. 1976). On the basis of the data available in 1973, the prediction was made that the last peregrine chick would fledge on the Colville River in 1975 and that the peregrine would disappear as a breeding species along the river by 1980 (Peakall et al. 1975).

Shell thinning of peregrine eggs (n = 27) collected on the Colville in 1968, 1969 and 1970 exceeded 20%, a threshold level above which productivity is not high enough to maintain a population (Peakall et al. 1975;

Hickey and Anderson 1968; Ratcliffe 1967). Levels of DDE, determined to be the cause of the thinning, exceeded the corresponding critical concentration of 20 ppm wet weight, or 100 ppm dry weight (Peakall et al. 1975). Since DDT use by that time had been discontinued in North America north of Mexico, and since use had declined in the 1960's prior to the ending of all uses in the United States and Canada, it appeared that peregrines in the arctic were accumulating high DDE levels on their wintering grounds in South America (Peakall et al. 1975).

Within Alaska in the mid-1970's, productivity and population viability differed significantly among the several river systems. The population on the Tanana River had all but disappeared by 1975. On the Yukon River, however, a smaller decline occurred and a substantial population remained in 1975. The extent of the decline on the Colville was about mid-way between that of the Tanana and the Yukon. In contrast, the Greenland peregrine population appears to have been stable throughout the 1970's (Mattox et al. 1980; Mattox, W. A. Burnham, W. S. Seegar, F. P. Ward, unpublished data) although it also winters in South America.

The differences in productivity could be explained if peregrines breeding on the Tanana and Colville rivers wintered in areas of relatively high DDT use in South America, and if the populations breeding on the Yukon River and in Greenland wintered in areas of relatively low DDT use (Peakall et al. 1975; Newton 1979). Alternatively, the species of prey eaten prior to egg-laying might be a more significant factor affecting reproductive success and residue concentrations in the eggs. Many of the shorebirds and other water birds eaten by peregrines in arctic Alaska (White and Cade 1971; Cade et al. 1968) also winter in South America where they are exposed to organochlorine contamination. Therefore, they remain sources of contamination to peregrines throughout the breeding season and could contribute to the residues in the eggs. The consumption prior to egg-laying of proportionally more non-migrant prey species and of migrant passerines, which contain substantially lower DDE residues than do aquatic birds (Cade et al. 1968; Burnham 1975), would be expected to decrease the level of organochlorines circulating in the blood and thus the levels incorporated into the eggs. The migration patterns of prey species, resulting in different patterns and levels of exposure to organochlorines in South America, might also be a contributing factor in explaining the observed differences in residue levels in peregrines, population declines, and reproductive success.

In this paper we present results of the analyses for a number of organochlorine pollutants in inviable eggs, shells of eggs that had hatched, and dead chicks obtained between 1977 and 1980 in Alaska and Greenland, and of a single egg obtained in Arizona in 1978. We compare these data with data on organochlorine residues in: 1) eggs of Peregrine Falcons obtained in 1978-79 in California, where the pattern of chlorinated biocide use is now significantly different from patterns prevailing in South America; and 2) eggs of peregrines from Colorado obtained in 1978, which are believed to winter south of the United States. If populations of northern peregrines winter in different areas of South America, differences in relative amounts of several of the chlorinated biocides — the HCH and chlordane compounds, heptachlor and heptachlor epoxide, dieldrin, endrin, and mirex — might be found. Alternatively, a "fingerprint" pattern of the proportions of different compounds that is equivalent among all northern peregrines might strengthen the hypothesis that the composition of the prey species taken on the breeding grounds immediately before egg-laying is an important factor contributing to the differential productivity.

Methods

Addled eggs, eggshell fragments and dead chicks were collected from peregrine eyries during field work between 1977 and 1980. Shell membranes of broken and hatched eggs were extracted by soaking for 12 hours in methylene chloride. Contents of whole eggs and livers of chicks were homogenized and an aliquot of each was removed for analysis. Approximately 5-10 grams (wet weight) of whole tissue was ground in anhydrous sodium sulfate and extracted in a soxhlet apparatus using methylene chloride. Lipids were removed by florisil column chromatography, eluting with hexane, 30% methylene chloride in hexane, and 50% methylene chloride in hexane, respectively. Extracts were analyzed with Carlo Erba 2350 gas chromatographs equipped with 30 meter SE-54 and SE-30 fused silica capillary columns and Brechtbuhler electron capture detectors. Confirmation of the identification of all compounds reported was made in selected extracts by gas chromatography-mass spectrometry.

Intercalibration between whole egg measurements of DDE and estimates of the DDE content of whole eggs derived from the analysis of eggshell membranes has demonstrated the comparability of data obtained from the two types of samples (Peakall et al. 1983). Dry weight equivalents of shell membrane determinations were calculated by dividing the ppm lipid weights by 4; the average percentage lipid of oven-dried aliquots of whole addled eggs had previously been determined to be 25 ± 7% (N = 17). The calculated concentrations of organochlorine compounds in whole eggs based on eggshell determinations include

therefore an additional component of variance, which is not judged to be of major significance. This variance component is not present, however, in determinations of the ratios of the organochlorine compounds in extracts of eggshell fragments.

Results and Discussion

DDE concentrations are presented in Table 1, and are compared with values previously published in the literature. Because samples consisted largely of inviable eggs, they may be biased toward the more contaminated members of the respective populations and rigorous statistical comparisons are not possible. Nevertheless, the DDE levels correspond to general patterns of population viability and reproductive success. The levels of DDE in the Amchitka eggs were relatively low, corresponding to a reduction of 7-8 % in shell thickness index, a change that has not affected the viability of the population (White et al. 1971; White et al. 1973; Peakall et al. 1975). DDE concentrations in the Greenland eggs were lower than the critical level of approximately 100 ppm dry weight

TABLE 1. DDE residues in eggs of arctic and subarctic Peregrine Falcons, a review. Parts per million of the dry weight, arithmetic means.[1]

Region	Year	Clutches	Eggs	DDE	Reference
Greenland	1972	2	2	83	2
	1978	5	5	80	3
	1979	2	3	49	3
Canada					
Ungava	1970	—	10	63	4
Mackenzie River	1968	—	7	100	5
Alaska, Aleutians					
Amchitka Island	1969	—	6	25	6
	1970	—	6	39.8	6
	1971	—	3	24.4	6
Alaska, Arctic	1973	—	7	26.3	6
Colville River	1967	—	3	130	7
	1968	—	11	194	6
	1969	—	5	164	6
	1971	—	7	210	6
	1978	2	2	160	3
	1979	3	5	56	3
Sagwon Bluffs	1974	1	1	530	3
	1977	1	1	150	3
	1979	1	4	84	3
Franklin Bluffs	1979	1	1	64	3
Yukon River	1966	—	2	48	8
	1968	—	11	106	6
	1977	2	2	68	3
	1979	1	1	16	3
	1980	2	2	33	3
Tanana River	1969	—	3	344	6
	1973	—	3	303	6
	1980	1	1	52	3
Kuskokwim River	1979	1	1	88	3
	1980	2	2	44	3
Porcupine River	1979	2	2	97	3
	1980	1	1	12	3
Charlie River	1980	1	1	39	3

[1]Dry weight as reported, or estimated assuming 80% water and 5% lipid in whole eggs. Mean values as reported, assume arithmetic means.
[2]Walker et al. 1973.
[3]This study.
[4]Berger et al. 1970.
[5]Enderson and Berger. 1968.
[6]Peakall et al. 1975.
[7]Lincer et al. 1970.
[8]Cade et al. 1968.

that has been associated with declining populations. Although reproductive failures have been observed, this population has generally maintained its status throughout the 1970's (W. G. Mattox personal communication). The high values from the Tanana River in 1969 and 1973, and from the Colville and Sagavanirktok rivers through 1977-78 correlate well with the documented population declines (Cade et al. 1971; Peakall et al. 1975; White and Cade 1977).

All of the eggs obtained after 1978 contained lower levels of DDE than those in eggs from previous years. Although sample sizes are small, the lower DDE values recorded in eggs obtained in 1978-1980 from Greenland, from the Colville and Sagavanirktok Rivers on the Alaskan Arctic Slope, and from the Yukon, Porcupine, Charlie, Tanana and Kuskokwim Rivers in the Alaskan interior indicate a general decrease in DDE levels in peregrine populations in the arctic and subarctic.

Data obtained from yearly surveys of productivity on the Colville, Sagavanirktok, Yukon and Tanana rivers through 1981 indicate a corresponding increase in productivity. On the lower section of the Yukon River, the number of nesting attempts (breeding pairs or single adults) from 1978 to 1981 were 29, 31, 39, and 43 respectively; the comparable minimum numbers of 3-4 week-old young were 28, 39, 69, and 68, respectively (A. M. Springer, unpublished data; Mindell and F. L. Craighead, unpublished data). On a section of the Colville where there were 13 active sites in 1975, the numbers in 1979-1981 were 21, 23, and 29, respectively (R. E. Ambrose personal communication). Similarly, numbers of active sites on the Tanana increased from one in 1974 to four in 1980 and five in 1981 (D. G. Roseneau unpublished data; J. R. Ritchie and J. A. Curatolo personal communication).

In part, the DDE residues accumulated by Peregrine Falcons breeding in the Arctic derive from global atmospheric fallout. This is the likely source of the majority of the DDE in resident peregrine populations in the Aleutians. An analysis of the composition of prey species found that 65 % by weight of the prey consisted of alcids wintering in the Aleutians; migratory species constituted less than 3 % of the total (White et al. 1971, 1973).

In spite of numerous monitoring programs, no data are apparently available that would document the magnitude of change in the atmospheric fallout of DDT compounds and of other organochlorines in the northern hemisphere. Atmospheric fallout, however, appears to be a minor source of the DDE accumulated by the Alaskan and Greenland peregrines. This can be inferred from: 1) a comparison between the relatively high residue levels in peregrines and the generally low values in Gyrfalcons, *Falco rusticolus*, breeding in close proximity but feeding largely on resident prey (Walker 1977); and 2) comparisons with the lower levels of DDE in the Aleutian population.

Because of the environmental stability of DDE, much of the DDE accumulated by North American Peregrine Falcons might have been derived from DDT applied many years ago. DDE of a relatively greater age might, however, be expected to be associated with comparatively low levels of the parent DDT compound, p,p'-DDT. DDE derived from DDT recently applied in South America would therefore be associated with comparatively high levels of p,p'-DDT, as well as with other organochlorine biocides currently used in South America.

Organochlorine residue data from eggs of peregrines breeding in Greenland, on the Arctic Slope and in the interior of Alaska, and from chicks found dead in interior Alaska over the years 1977-1980 are summarized in Table 2. They are compared with a data set from eggs of peregrines breeding in California obtained by the same analytical methodology (R. W. Risebrough, unpublished data), and with data on residues in eggs from Colorado obtained in 1978 and analyzed by the Patuxent Wildlife Research Center, U.S. Fish and Wildlife Service (J. H. Enderson, personal communication). Also presented are residue data from a single egg obtained in Arizona in 1978.

Highest values of the parent DDT compound, p,p'-DDT, were present in the eggs from arctic Alaska, from Colorado and in the single egg from Arizona. Most likely, the p,p'-DDT in the Colorado and Arizona eggs derives from recent usage in Mexico. Dieldrin levels appear to be substantially lower in the California peregrine eggs than in eggs from Alaska and Greenland. Like DDT, dieldrin is no longer used in California. Chlordane, from which the nonachlors and oxychlordane are derived, and endrin are still used in California; levels of these compounds among the arctic and California birds are generally of the same order. Mirex is not used in California and levels were substantially lower than those in the Alaskan and Greenland eggs. This biocide is being increasingly used in Latin America for the control of ants (Springer and Risebrough, unpublished data). Levels of the HCH compounds and of HCB, both of which are widely dispersed through the atmosphere (Atlas and Giam 1981; Tanabe et al. 1982) were approximately equivalent among all the areas. Levels of all compounds were lower in the broods of peregrine chicks analyzed from the Alaskan taiga.

Regional differences become more pronounced when ratios of individual compounds to DDE are considered. Differences among these ratios were examined with the Mann-Whitney U Test. Probabilities considered significant (< 0.05) are presented in

TABLE 2. Organochlorine residues in eggs and chicks of Peregrine Falcons from Greenland and the United States, 1977-1980.[1] Geometric means of clutch or brood arithmetic means, with an interval of one S.D. Number of clutches or broods analysed in parentheses. Parts per million of the dry weight.

Location	p,p'-DDE			p,p'-DDD			p,p'-DDT		
Greenland	61	34 – 110	(7)	0.65	0.26 – 1.6	(7)	0.23	0.10 – 0.56	(7)
Alaska, Arctic	86	50 – 148	(8)	0.38	0.15 – 0.92	(7)	0.46	0.059 – 3.5	(7)
Alaska, Taiga									
(clutches)	44	21 – 91	(14)	0.22	0.050 – 0.97	(11)	0.18	0.042 – 0.75	(11)
(broods)	15	9 – 27	(2)	0.015	0.004 – 0.047	(2)	0.002	0.001 – 0.004	(2)
California[2]	130	86 – 190	(12)	0.27	0.13 – 0.57	(11)	0.12	0.062 – 0.22	(11)
Colorado[3]	95	47 – 141	(4)	0.098	0.025 – 0.038	(4)	0.52	0.093 – 2.9	(4)
Arizona	33	–	(1)	0.07	–	(1)	0.50	–	(1)

Location	α-HCH			β-HCH			γ-HCH		
Greenland	0.046	0.023 – 0.093	(7)	0.40	0.12 – 1.3	(7)	0.018	0.007 – 0.045	(6)
Alaska, Arctic	0.074	0.022 – 0.25	(7)	0.92	0.47 – 1.8	(7)	0.013	0.003 – 0.052	(6)
Alaska, Taiga									
(clutches)	0.028	0.014 – 0.055	(7)	0.52	0.21 – 1.3	(7)	0.0056	0.0014 – 0.021	(7)
(broods)	0.0065	0.0043 – 0.0094	(2)	0.047	0.019 – 0.11	(2)	0.0008	0.0002 – 0.0030	(2)
California[2]	0.030	0.021 – 0.042	(11)	0.25	0.14 – 0.45	(11)	0.010	0.0051 – 0.020	(11)
Colorado[3]	nm[4]			1.0	0.82 – 1.3	(3)	nm[4]		
Arizona	0.08	–	(1)	0.49	–	(1)	< 0.005	–	(1)

Location	Mirex			HCB			PCB		
Greenland	0.57	0.28 – 1.2	(7)	0.35	0.10 – 1.2	(6)	29	11 – 72	(7)
Alaska, Arctic	0.96	0.46 – 2.0	(8)	0.15	0.087 – 0.27	(7)	22	13 – 37	(7)
Alaska, Taiga									
(clutches)	1.6	0.67 – 3.6	(13)	0.15	0.025 – 0.94	(11)	20	10 – 41	(11)
(broods)	0.33	0.31 – 0.34	(2)	0.042	0.027 – 0.064	(2)	2.8	0.63 – 13	(2)
California[2]	0.13	0.045 – 0.37	(11)	0.34	0.17 – 0.71	(11)	41	28 – 60	(11)
Colorado[3]	nm			nm			3.9	1.1 – 14	(4)
Arizona	< 0.02	–	(1)	0.29	–	(1)	0.96	–	(1)

Location	Dieldrin			Endrin			Heptaclor epoxide		
Greenland	2.0	0.99 – 4.2	(7)	0.12	0.029 – 0.53	(6)	0.90	0.46 – 1.7	(7)
Alaska, Arctic	4.6	1.9 – 11	(7)	0.11	0.054 – 0.22	(6)	2.4	0.88 – 6.6	(7)
Alaska, Taiga									
(clutches)	1.8	0.60 – 5.4	(12)	0.050	0.016 – 0.15	(10)	0.68	0.26 – 1.8	(11)
(broods)	0.36	0.20 – 0.63	(2)	0.0040	0.0032 – 0.0051	(2)	0.20	0.057 – 0.70	(2)
California[2]	0.73	0.51 – 1.1	(12)	0.068	0.034 – 0.13	(11)	0.44	0.23 – 0.87	(12)
Colorado[3]	1.1	0.80 – 1.5	(4)	nm[4]	–		2.9	2.1 – 4.1	(4)
Arizona	0.34	–	(1)	0.20	–	(1)	0.76	–	(1)

Location	cis-Nonachlor			trans-Nonachlor			Oxychlordane		
Greenland	nm[4]			0.11	0.032 – 0.40	(6)	0.68	0.36 – 1.3	(7)
Alaska, Arctic	0.11	0.067 – 0.19	(4)	0.17	0.062 – 0.49	(7)	1.2	0.52 – 2.7	(7)
Alaska, Taiga									
(clutches)	0.065	0.020 – 0.21	(10)	0.12	0.025 – 0.53	(11)	0.39	0.14 – 1.1	(11)
(broods)	0.015	–	(1)	0.023	0.0022 – 0.23	(2)	0.18	0.061 – 0.55	(2)
California[2]	nm			0.067	0.022 – 0.21	(11)	1.5	0.93 – 2.3	(11)
Colorado[3]	nm			0.16	–	(1)	0.44	0.10 – 1.9	(4)
Arizona	nm			0.01	–	(1)	0.49	–	(1)

[1]One egg obtained from California in 1975, one in 1976.
[2]Unpublished data from Risebrough.
[3]Data from Enderson (personal communication).
[4]not measured.

TABLE 3. Probabilities[a] that ratios of concentrations of selected organochlorine pollutants to concentrations of p,p'-DDE in eggs of Peregrine Falcons do not differ.

Locations[b]	p,p' – DDT + p,p' – DDD	Dieldrin	Endrin	Heptachlor epoxide	Oxy-chlordane	trans-Nonachlor	Mirex	β – HCH	PCB
GR – AA	–	0.05	–	–	–	–	–	–	–
GR – AI	–	–	–	–	–	–	0.003	–	–
AA – AI	–	–	–	–	–	–	0.002	–	0.02
GR – CA	< 0.0001	0.002	–	0.003	–	–	< 0.0001	0.04	< 0.0001
AA – CA	0.0007	< 0.0001	0.04	0.0007	–	0.03	< 0.0001	0.008	–
AI – CA	0.0003	0.0001	–	0.0006	–	0.01	< 0.0001	0.004	0.03
GR – CO	–	–	nd[c]	–	–	–	nd	–	< 0.0001
AA – CO	–	0.02	nd	–	–	–	nd	–	< 0.0001
AI – CO	–	0.04	nd	–	–	–	nd	–	< 0.0001
CA – CO	–	–	–	0.005	–	–	–	0.02	< 0.0001
Ie – Ic	< 0.0001	–	–	–	–	–	–	–	–

[a]Probabilities greater than 0.05 are not listed.
[b]Locations: GR Greenland; AA Alaska Arctic; AI Alaska Interior; CA California; CO Colorado; Ie Alaska Interior eggs; Ic Alaska Interior chicks.
[c]not determined.

Table 3. The ratio of DDE to the sum of p,p'-DDD and p,p'-DDT, considered a more meaningful comparison than that with the parent p,p'-DDT alone, was significantly lower in Alaska and Greenland clutches than in those from California, reflecting exposure in areas of recent DDT applications. Levels of dieldrin, heptachlor epoxide (derived from heptachlor) and mirex were all comparatively higher, relative to DDE, in the Greenland and Alaskan eggs than in those from California.

A higher proportion of dieldrin in the Arctic Slope eggs than in those from Greenland, comparatively higher levels of mirex in interior Alaska and a higher PCB: DDE ratio in interior Alaska than in arctic Alaska indicate regional differences in exposure patterns, either on the wintering grounds in South America or through the consumption of prey on the breeding grounds.

In Table 4 the ratios of the sum of p,p'-DDT and p,p'-DDD to the other organochlorines are examined.

TABLE 4. Probabilities[a] that ratios of concentrations of selected organochlorine pollutants to concentrations of p,p' – DDT + p,p' – DDD in eggs of Peregrine Falcons do not differ.

Locations[b]	Dieldrin	Endrin	Heptachlor epoxide	Oxy-chlordane	trans-Nonachlor	Mirex	β-HCH	PCB
GR – AA	–	–	–	–	–	–	–	–
GR – AI	–	–	–	–	–	–	–	–
AA – AI	–	–	–	–	–	–	–	0.03
GR – CA	–	–	–	0.004	–	–	–	0.006
AA – CA	0.009	–	–	0.02	–	–	–	0.007
AI – CA	–	–	–	0.02	–	0.02	–	0.02
GR – CO	–	nd[c]	0.02	–	–	nd	–	–
AA – CO	–	nd	–	–	–	nd	–	–
AI – CO	–	nd	–	–	–	nd	–	0.05
CA – CO	–	–	–	–	–	–	–	–
Ie – Ic	–	–	–	–	–	0.04	–	–

[a]Probabilities greater than 0.05 are not listed.
[b]Locations: GR Greenland; AA Alaska Arctic; AI Alaska Interior; CA California; CO Colorado; Ie Alaska Interior eggs; Ic Alaska Interior chicks.
[c]not determined.

Except for proportionally more PCB in the Alaskan interior than on the Arctic Slope, there are no differences among the three northern areas, indicating generally common patterns of exposure to organochlorines used in Latin America but not in the USA or Canada. In comparing the northern birds with those from California, consistent differences appear in the ratio of p,p'-DDT + p,p'-DDD to oxychlordane and PCB, reflecting lower levels of the two DDT compounds in the California environment and higher levels of PCB and oxychlordane. The oxychlordane is derived from chlordane compounds still in current use in California.

The data provide, therefore, no clear support for the hypothesis that differences in residue concentrations among breeding peregrines of the Arctic and of interior Alaska result from differential exposure to organochlorines in Latin America. The observed differences could result from the consumption of different proportions of migrant and resident species prior to egg laying.

As the data base on organochlorine residue contamination in South America and other areas of Latin America is expanded, regional differences in both the patterns of contamination and levels of individual compounds might be anticipated. It would appear worthwhile, therefore, to continue to examine the "fingerprint" patterns of contamination in all peregrine material as it becomes available. Larger sample sizes obtained over time might be expected to yield additional information.

In 1977 Argentina canceled the uses of DDT formulations as liquid emulsions (Resolution 807, 10 November 1977, Ministry of Agriculture and Livestock), one of a series of restrictions on applications of organochlorine insecticides implemented in recent years. In southern Brazil the use of DDT and other organochlorines has also recently decreased as policies have been adopted that were based on those previously implemented in Europe and North America (M. Sander, Springer, and Risebrough, unpublished data). Although DDT use elsewhere in Latin America continues, an overall reduction in DDT use in Latin America appears to have contributed to the partial recovery of the peregrine populations breeding in Alaska.

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The Status of Western Larch, *Larix occidentalis*, in Alberta

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The Western Larch (*Larix occidentalis*), a rare tree in Alberta, was previously known from two locations, one of which was the result of intentional planting. Three areas of natural occurrence are here reported from the mountains of southwestern Alberta. The largest occurrence (71 sites) is found within Kananaskis Provincial Park and the adjacent lower Kananaskis Valley. Additional sites are described from the Crowsnest Pass and Bow Valley. A report from Waterton Lakes National Park is apparently erroneous. Western Larch in Alberta appears to have originated from seed transported through low mountain passes across the continental divide from British Columbia. Present populations may have been established following fires in 1858 and 1890 in the Kananaskis Valley. Fire suppression may hamper its long-term survival in western Alberta.

Key Words: Western Larch, *Larix occidentalis*, Alberta, fire, rare flora, Columbia Forest Region.

The Western Larch (*Larix occidentalis*) is a characteristic tree of the Columbia Forest Region (Hosie 1969; Rowe 1972) in southern British Columbia (Figure 1). It is particularly abundant in the first stages of forest succession following disturbance (usually by fire), and often is associated with Douglas Fir (*Pseudotsuga menziesii*). It is an important timber species. It is rare in Alberta (Argus and White 1978) and was previously documented from only a single tree in the Kananaskis Valley (Moss 1959). Hosie (1969) refers to "... a few trees ... in the Kananaskis Valley and southward in the foothills. ..." Boivin (1967) also cites the Kananaskis station, as well as one in the Crowsnest Pass. An unpublished study (P. J. Murphy. 1960. Report on the Occurrence of Western Larch (*Larix occidentalis*) in the Kananaskis Valley. Canadian Forestry Service, Edmonton) reports "... one group in the Crowsnest Pass ... [and] we also understand that there are some in Waterton Lakes National Park ..." With the origin of the Kananaskis tree(s) in doubt (located at the Kananaskis Forest Experiment Station where exotic tree introductions have occurred since the 1940's) and only vague references to other stations, the status of Western Larch in Alberta has been in question.

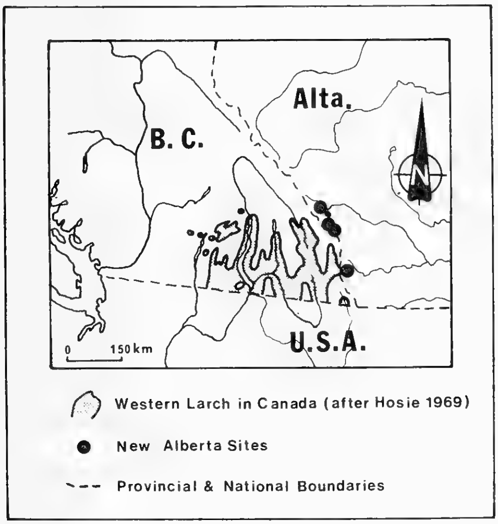

FIGURE 1. The distribution of Western Larch in Canada

Here, I report the results of a search for Western Larch in southwestern Alberta and describe three areas of occurrence of this species in the province.

Methods

To locate Western Larch trees, roadside surveys were conducted in late September and in October, 1977 and 1978, along Highway 1 between Seebe and Banff (in the Bow Valley) and along the Kananaskis Highway between Highway 1 and Highwood Pass (in the Kananaskis Valley), including the Avalanche Viewpoint, Kananaskis Valley Viewpoint, Lakes Viewpoint, Interlakes Lookout Trail and the Kananaskis Fire Lookout. I scanned the surrounding mountain slopes and valley bottom with 7 × 50 power binoculars, and could usually pick out individual Western Larch trees (in clear weather) at distances of up to 6.5 km.

At this time the deciduous leaves of Western Larch have turned a deep golden yellow colour and provide striking contrast to the associated dark green foliage of Lodgepole Pine (*Pinus contorta*), Subalpine Fir (*Abies lasiocarpa*), Douglas Fir, and hybrid White Spruce (*Picea glauca* × *engelmannii*).

Western Larch is very similar in appearance to

Alpine Larch (*Larix lyallii*) which is common at higher elevations (usually at treeline) in this area. Alpine Larch leaves exhibit a brighter, more intense colour in contrast to the dull golden-yellow characteristic of Western Larch, and could be easily separated from it in most cases. Examination of sites discovered during the binocular surveys was made whenever possible to confirm sightings. When trees were examined closely, the densely hairy buds and recurved cone scales of Alpine Larch were the primary characteristics used to separate this species from Western Larch (which exhibits glabrous or, at most, lightly pubescent buds and straight cone scales). Care also had to be taken not to confuse Western Larch with Black Cottonwood (*Populus balsamifera* var. *trichocarpa*) which at a distance exhibits the same dull, golden-yellow colour in this season. The coarser-textured, broader-leaved and more rounded profile of the Cottonwood usually was apparent. When doubt remained, that site was not counted.

A brief roadside survey was also conducted along Highway 3 in the Crowsnest Pass between Blairmore and the British Columbia border and along the Forestry Trunk Road between Colman and Highwood Pass (foothill area) on 28 and 29 July 1978. At this time the leaves of Western Larch were still green and the trees were much more difficult to pick out from the surrounding forest.

Herbarium acronyms cited in this paper follow Boivin (1980).

Results and Discussion

Western Larch was located at 71 sites in the Kananaskis Valley (67 in Kananaskis Provincial Park), constituting a total of about 175 individual trees. (A 'site' was defined as a single or group of trees conspicuously separated from other such specimens). One additional site was found in the Bow Valley and another was located in the Crowsnest Pass, each containing only a single tree (Figures 1 and 2). Voucher specimens supporting records for the Kananaskis Valley include *Brunton 1286* (DAO, CAN, DFB, ALTA); *Brunton 1406* (DAO, DFB) & *D. R. Jaques 4805* (UAC). The Crowsnest Pass station, *Brunton 1615* (DAO, DFB) is on the north side of Highway 3, 0.2 km east of the British Columbia border. A voucher specimen was not obtained from the tree that was observed in the Bow Valley in October 1978 (7.2 km southeast of Canmore on slopes above Deadman's Flats 150 m south of Highway 1).

The report by Murphy (unpublished) of specimens in or near Waterton Lakes National Park could not be confirmed. Kuijt (1982) does not list Western Larch in his Waterton Park flora nor are any stands known in that area by other workers who have looked for it (V. Loewen, P. McIssac and J. Gould. 1979. Natural Area Inspection Report: Island Lake. Ecological Reserves Program, Alberta Department of Natural Resources, Edmonton). Loewen et al. (unpublished) do report an additional site (a single tree) on an island in Island Lake in the Crowsnest Pass and C. Wallis discovered a sizeable (though uncounted) population along the provincial border south of Highway 3 in the Crowsnest Pass (C. Wallis, J. Gould, personal communication).

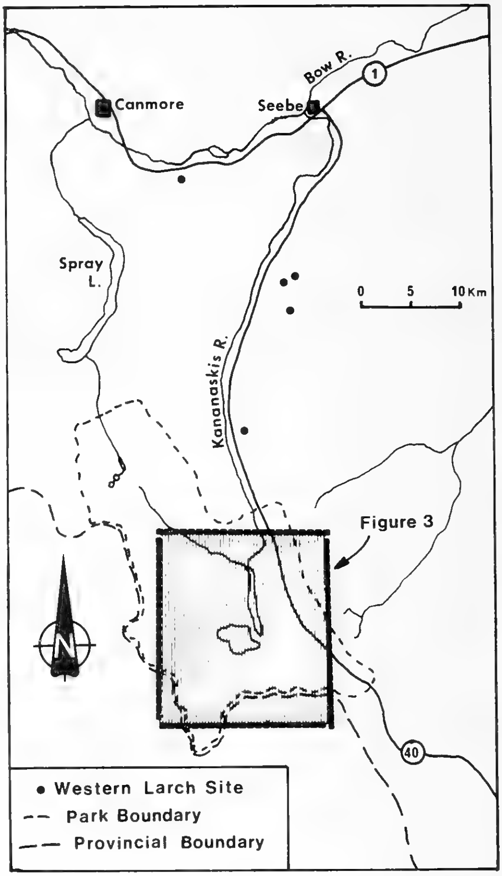

FIGURE 2. Western Larch in the lower Kananaskis and Bow Valleys of southwestern Alberta

The Western Larch sites in Kananaskis Provincial Park vary in elevation from 1660 m to 2075 m. The average of 67 sites is 1856 m. Most of these sites (75%) are on northfacing slopes associated with Lodgepole Pine, Subalpine Fir and hybrid White Spruce in moist, moss-covered, gravelly soil. In the four sites in

the lower Kananaskis Valley, elevations vary from 1495 m to 1601 m (averaging 1550 m). These westfacing sites are drier than the Kananaskis Park sites and are dominated by Lodgepole Pine with scattered Douglas Fir. The Bow Valley site and those in the Crowsnest Pass are similar to those in the lower Kananaskis Valley.

Western Larch is highly shade intolerant and develops best in open situations (Hosie 1969). Most of the Kananaskis Park trees are found in rather closed forests, however, and relatively little suitable habitat appears to be present. Murphy (unpublished) suggests that the Kananaskis populations are the result of regeneration following large fires. Brad Hawkes (1978. A Fire History and Fuel Appraisal Study of Kananaskis Provincial Park. Alberta Department of Recreation Parks and Wildlife, Edmonton) indicates that the Kananaskis Valley underwent a regular pattern of forest fires (16 burns between 1712 and 1920), with an average interval between fires of 14 years. That interval has increased greatly since fire suppression was effected; much of the Kananaskis Valley is 'over-due' for a major burn. This unnaturally mature forest cover may explain why Western Larch is usually found here in closed forest sites and with no evidence of regeneration.

Hawkes (unpublished) illustrates the extent of a large fire that swept through much of Kananaskis Park in 1858. Its extent matches the present-day distribution of Western Larch in Kananaskis Park to a remarkable degree (Figure 3). Murphy (unpublished) dated two of the trees near the Kananaskis Lakes at about 1890 (1887 and 1891, respectively). Hawkes (unpublished) describes a large fire (which occurred within the limits of the 1858 burn) that covered the site of the trees which Murphy sampled.

No other age data are available but from the work which has been done it seems reasonable to speculate that the Kananaskis Park Western Larch arose from seed transported across Elk Pass during or after the fire of 1858. These sites are all found close to the Continental Divide and within a relatively short (straight-line) distance of well-established British Columbia populations (Figure 1). Fowells (1965) notes that the seed of Western Larch is well suited to dispersal by wind (with very large wings on the seed in relation to the seed weight) and that it germinates twice as well on recently burnt ground (*versus* unburnt ground) and over three times as well on bare mineral soil (*versus* unburned, duff-covered ground). In addition, he points out that it prefers moist northfacing slopes and is even more fire resistent (as a full grown tree) than Douglas Fir.

Murphy (unpublished) dated several other Western Larch in the lower Kananaskis Valley at about 1890,

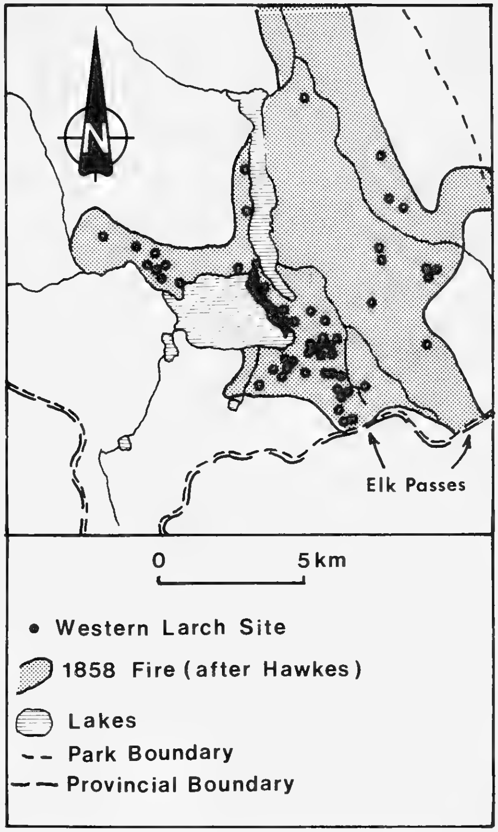

FIGURE 3. Distribution of Western Larch in Kananaskis Provincial Park, in relation to the extent of the fire of 1858

as well as one from 1936 (the year of a major fire in that area). The few isolated trees in the lower Kananaskis Valley and adjacent Bow Valley may have resulted from 'spot fires' which were ignited by wind-carried embers. Such spot fires are known to occur in this area at least 5 km in front of large fires (Hawkes unpublished).

There are only three passes across the continental divide which are below 2075 m (the maximum elevation of Western Larch in Alberta) and are also adjacent to the British Columbia range of the species. These are: Akamina Pass (Waterton Lakes National Park) 1780 m; Crowsnest Pass 1400 m; and Elk Pass (Kananaskis Park) 1965 m. Western Larch is known from two of these. While it is reasonable to assume that the heat-generated winds associated with forest

fires could push 'flying' seeds of Western Larch much higher than the elevations of these passes, it is likely that more seeds/hectare would be deposited in those areas of suitable habitat in the Alberta mountains that are closer to the seed source in British Columbia. The funnelling effect of these passes would also tend to concentrate the wind and hence the seed carried in it. In addition, some of the larger fires (which result in a superior seed bed for Western Larch being established) originate in British Columbia and sweep across the continental divide through these passes (Hawkes unpublished). This could establish a virtually continuous avenue of suitable sites for the species from its established range eastward into Alberta. With forest maturation and the supression of fire, Western Larch may have died out in many of these sites in between, remaining only in those particularly well-suited sites in the Kananaskis and Bow Valleys.

In July 1979 I observed scattered Western Larch trees on the British Columbia side of the Crowsnest Pass along Highway 3. This suggests that the three Alberta stations in the Crowsnest Pass are the eastern extremity of a continuous population that extends much further westward. It may also reflect contemporary rather than historic ecological factors (as opposed to the situation with the Kananaskis-Bow Valley trees).

It is evident that Western Larch is well established (if very local) in western Alberta. Further investigations in the Crowsnest Pass and Bow Valley (and possibly Waterton Lakes National Park) will likely uncover additional sites. A study to correlate the age of these trees with the fire history of such areas could clarify the origin and dispersal of Western Larch, the effect of fire suppression practices on forested lands and the long term survival of this fire-dependent species in southwestern Alberta.

Acknowledgments

The field work in the Kananaskis Valley was undertaken while I was employed as Interpretive Coordinator at Kananaskis Park for the Alberta Department of Recreation, Parks & Wildlife. I would like to thank N. Kondla (of that department) for bringing the Murphy paper to my attention and Joyce Gould of the University of Toronto for providing a variety of important field data concerning the Crowsnest Pass sites. My thanks too to P. M. Catling for his very helpful review of an earlier draft and to referee George W. Argus for a detailed, creative and extremely useful critique of the submitted manuscript. Finally, my thanks to Editor Francis Cook for his patient endurance of my procrastination in manuscript revision that would have made mere tardiness appear to be rash impulse!

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Additions to the Vascular Plant Flora of the Bathurst Inlet Region, Northwest Territories

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Cody, W. J., G. W. Scotter, and S. C. Zoltai. 1984. Additions to the vascular plant flora of the Bathurst Inlet Region, Northwest Territories. Canadian Field-Naturalist 98(2): 171–177.

Forty-two species are added to the known flora of the Bathurst Inlet region as a result of field surveys of 32 localities in 1979. Bathurst Inlet lies entirely beyond the treeline and within the Canadian Shield, with five plateau regions. Phytogeographic affinities of the known flora of about 260 species are 63% circumpolar, 13% amphi-Beringian, 3% amphi-Atlantic, 20% North American and 1% Cordilleran.

Key Words: Vascular plants, Bathurst Inlet, Northwest Territories.

The vascular plant flora of the Bathurst Inlet region has been reported by Cody (1954) and Porsild and Cody (1980). A natural resource survey of the Bathurst Inlet region was undertaken by the Canadian Wildlife Service and Canadian Forestry Service during 1979 because of its potential as a possible new national park. As a result of this survey, a total of 42 species was added to the vascular plant flora. The purpose of this paper is to record these range extensions.

Bathurst Inlet lies beyond the tree line and consequently is wholly within the arctic tundra region. Broad variation in vegetation is found. The southern part has a luxuriance of lowland vegetation. Shrub growth of birch and willows in the river valleys and in protected spots reaches 2–3 m in height. Farther north along the Inlet are dwarf-shrub heath, damp tundra of sedge and cottongrass, and dry heath tundra. Much of the upland is rock desert with scattered cover of cushion plants, prostrate shrubs, lichens, and bryophytes.

The vegetation of the study area is dominated by species characteristic of the Low Arctic tundra. In favourable locations, tall shrubs, found in the High Subarctic region, occur. The prevalence of various special habitats results in a surprisingly rich vascular flora, much more diverse than would be expected. From previous reports and the results of the present survey, approximately 260 vascular plants are known from the region. The phytogeographic affinities of those species are: 164 circumpolar (63%), 34 amphi-Beringian (13%), 9 amphi-Atlantic (3%), 51 North American (20%), and 2 Cordilleran (1%).

Bathurst Inlet (Figure 1) is on the mainland of the western Canadian Arctic, roughly half way between the mouth of the Mackenzie River and Boothia Peninsula. The inlet is a complex, submerged valley that penetrates from the east end of Coronation Gulf in a southeasterly direction about 200 km into the barren grounds.

The Bathurst Inlet area lies wholly within the Canadian Shield. The Inlet itself and its adjacent lowlands can be regarded as a long narrow southward extension of the Coronation Gulf lowlands penetrating the Canadian Shield, which forms plateaus to east and west (Bird and Bird 1961): Contwoyto Plateau, Wilberforce Hills and the Tree River Uplands to the west, and the Buchan and Bathurst Drift Upland to the east.

The Contwoyto Plateau is in general high (450 m), gently rolling, and mantled with drift, with the Wilberforce Hills as its rough dissected edge. The Tree River Upland is a lower, dissected granite plateau of smoothed rock-knob hills separated by deep valleys, into which drift deposits have been washed.

The Buchan Upland northeast of Bathurst Inlet is similar to the Tree River Upland although somewhat lower — a granite peneplain eroded into bare rock-knob hills. Drift washed into the valleys supports damp tundra, though many are blocked, forming elongated or cruciform lakes. The Bathurst Upland to the southeast resembles the Contwoyto Plateau. Near Gordon Bay this upland surface is deeply dissected. Further south, to the east of Western River, there has been less dissection; but both areas are rocky. The rock surface is thinly mantled with till further east towards the Ellice River (outside map). The Bathurst Drift Upland is more generally covered with till, often drumlinised.

The boundary between the uplands and the Coronation Gulf lowlands is formed on the west side of the inlet by a major fault running north-northeast to south-southwest from Daniel Moore Bay to Bathurst

Lake with a horizontal left-hand displacement of about 80 km (Fraser 1964).

Bird and Bird (1961) differentiate three main regions within the lowland region: the Bathurst Cuestas, the Southwest Bathurst Ridges and the Gordon Bay Hills.

The cuesta region is partly drowned, forming the maze of elongated islands. The Bathurst Islands and the Arctic Sound-Banks cuestas are similarly formed of westward-dipping diabase and basalt sills, usually overlying dolomites, and often with precipitous east faces. The Goulburn cuestas of eastern Banks peninsula are formed on metamorphic rocks, chiefly quartzite and slate, and are separated by vales of clay till. The fourth subregion of the Bathurst cuestas is the Burnside Lowlands, a zone of sandy till and marine silt lowlands, rising in the southern part into low parallel ridges. This region contains the Hood and Burnside deltas.

The Southwest Bathurst Ridges subregion is formed of parallel rock ridges separated by till lowlands. These are drumlinized parallel to the strike of the rocks, so that almost all features of the landscape are oriented south-southeast to north-northwest.

The Gordon Bay Hills form a comparatively low but rugged region to the south of Gordon Bay. That region has developed on slates, quartzites and dolomitic limestone.

In addition to the above, Campbell and Cecile (1976) and Campbell (1978) give information on the physiography and geology of the region.

The climate of Bathurst Inlet varies along its length (Bird and Bird, 1961). The winters are cold, the uniform northwest-southeast orientation of topographic features tends to channel the prevailing winds along the length of the Inlet, and there are places where the wind only blows one direction or the other. The winter climate is among the most severe in the Canadian Arctic. The mean daily January temperature is −35 to −33°C with 80% frequency of temperature inversions and 5-10% occurrence of blizzards (Maxwell, 1981). The winter begins ca. August 25 and ends ca. June 15.

Summer weather at the south end of the Inlet is relatively mild. The region is protected by the length of the Inlet from the cooling influence of the Arctic sea, but has a sea-level altitude. Dry westerly winds blowing down from the uplands have a warming influence. Summer temperatures are not as high on the adjacent uplands and deteriorate northward along the length of the Inlet as cooling effects from Coronation Gulf become more significant. The July mean daily temperatures are about 5-3°C with 15-20 days of fog with temperature inversions still occurring around 40% of the time (Maxwell 1981). Annual precipitation is low, increasing slightly toward the northern end of the Inlet, about 125 mm, with ca. 40% falling as rain.

In the course of the survey, 32 sites were studied. The locations of these sites are indicated on Figure 1. Latitudes, longitudes and elevations in meters above sea level of the collection sites from which specimens are cited in this paper (given in parentheses after voucher number) are:

1. Rock lichen, *Ledum*-moss, *Alnus-Carex* community types, 0 – 335 m, Near Bathurst Inlet Lodge, 66°51′N, 108°02′W, 29 July 1979.
2. Heath-lichen community type, 130 – 145 m, Near Wilberforce Falls, 67°05′N, 108°47′W, 29 July 1979.
3. *Carex-Eriophorum* community type, 9 m, 66°58′N, 108°24′W, 30 July 1979.
4. Heath and *Carex* community types, 60 m, 67°05′N, 108°17′W, 30 July 1979.
5. Herb community type, 0 – 40 m, Near Goulburn Lake, 67°22′N, 108°23′W, 30 July 1979.
7. Near Twin Caves, Stockport Island, 0 – 15 m, 67°45′N, 108°59′W, 30 July 1979.
8. *Dryas*- heath community type, 0 – 4 m, Near Baillie Bay, 67°22′N, 108°51′W, 30 July 1979.
10. Rock lichen and *Carex* community types, 175 m, 67°09′N, 107°31′W, 31 July 1979.
11. *Salix-Carex, Betula-Salix* and lichen community types, 0 – 30 m, Near Fowler Bay, 67°16′N, 107°32′W, 31 July 1979.
12. *Dryas-Potentilla* community type, 50 – 75 m, 67°29′N, 107°34′W, 31 July 1979.
13. *Carex-Salix* community type, 0 – 5 m, Near Bay Chimo, 67°42′N, 107°59′W, 31 July 1979.
14. Lichen, *Dryas*-heath and *Dryas-Carex* community types, 0 – 15 m, Near Buchan Bay, 67°52′N, 107°50′W, 31 July 1979.
16. *Dryas*-heath and *Carex* community types, 25 m, Near Hiukitak River, 67°09′N, 106°57′W, 31 July 1979.
17. *Ledum-Empetrum* and Lichen-*Ledum* community types, 75 – 90 m, 66°55′N, 106°45′W, 1 August 1979.
19. Legume-*Dryas* and lichen-moss community types, 180 – 200 m, Near Gordon River, 66°34′N, 106°41′W, 1 August 1979.
20. Heath, *Carex-Sphagnum* community types, 240 – 255 m, 66°09′N, 106°10′W, 1 August 1979.
21. *Dryas*-Legume and *Salix-Betula* community types, 60 – 90 m, Near Western River, 66°06′N, 106°52′W, 1 August 1979.
22. *Dryas* and *Alnus-Salix* community types, 10 m, Near delta of Western River, 66°22′N, 107°08′W, 1 August 1979.
23. Rock lichen and *Carex* community types, 150 m, 67°42′N, 107°34′W, 1 August 1979.

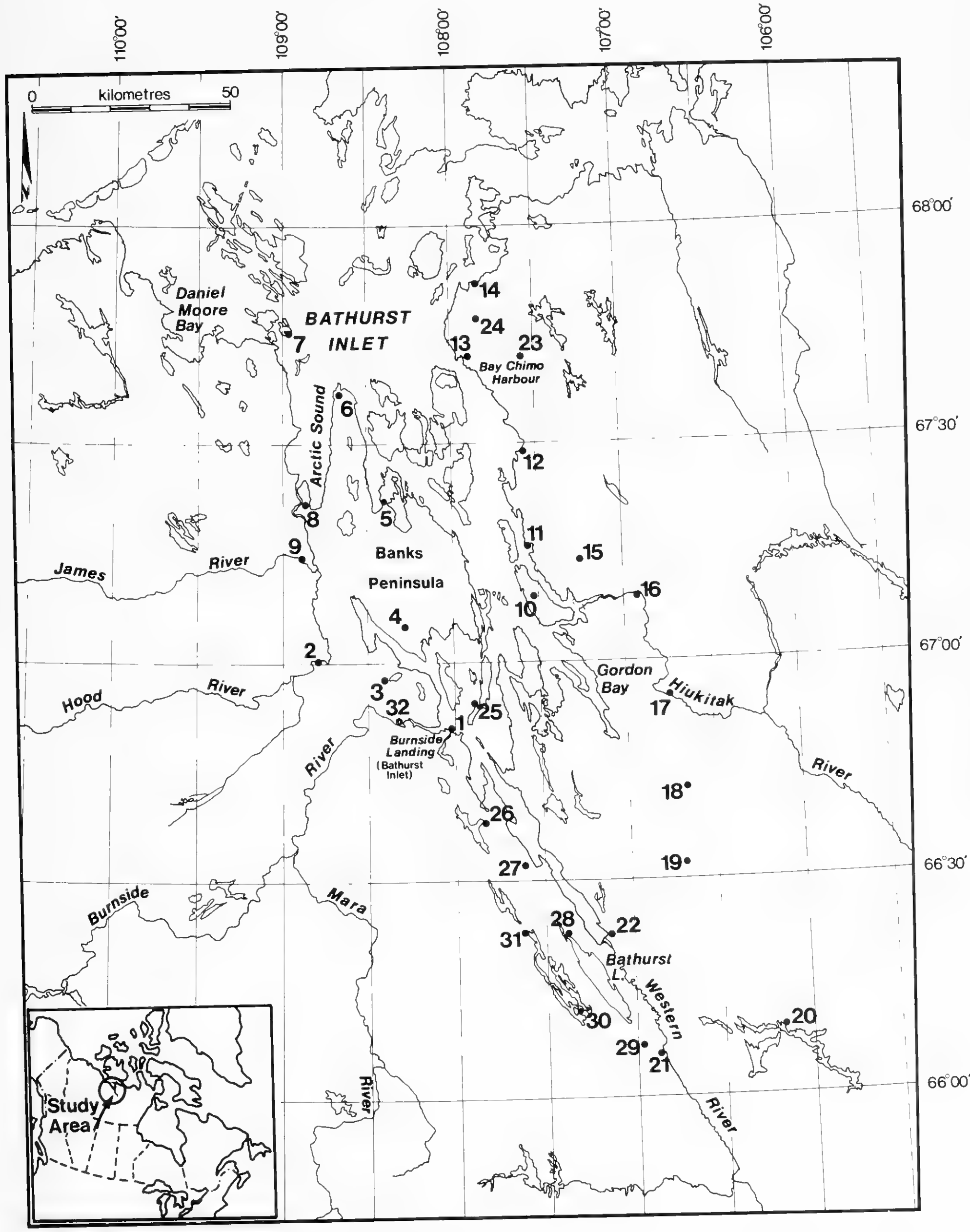

FIGURE 1. Locations of survey sites in the Bathurst Inlet region.

24. Legume-*Dryas*, 0 – 8 m, 67°47′N, 107°50′W, 1 August 1979.
25. Lichen communities on raised beaches, 0 – 35 m, Near Quadyuk Island, 66°54′N, 107°53′W, 1 August 1979.
26. *Salix-Dryas*, lichen-moss and *Carex* community types, 90 – 120 m, Near "Window Falls", 66°38′N, 107°50′W, 2 August 1979.
32. Lichen-moss community type, 50 – 60 m, Near Burnside Falls, 66°52′N, 108°18′W, 2 August 1979.

In the list of range extensions which follows the voucher numbers are those of Scotter and Zoltai. The first set of voucher specimens has been deposited in the herbarium of the Biosystematics Research Institute, Department of Agriculture, Ottawa (DAO). Some duplicates have been deposited in the herbarium of the Canadian Forestry Service, Edmonton (CAFB). Nomenclature follows Porsild and Cody (1980). The identifications were by Cody.

ASPIDIACEAE

Woodsia ilvensis (L.) R. Br., Rusty Woodsia, *31623* (1), *31947* (23) — These collections help to complete our knowledge of the northern distribution in Continental Northwest Territories as shown by Porsild and Cody (1980). The only other Arctic Coast site is at Coppermine.

EQUISETACEAE

Equisetum scirpoides Michx., Dwarf Scouring-Rush, *31919* (21) — This collection helps fill in the knowledge of the distribution between Liverpool Bay, the east end of Great Bear Lake, and King William Island as shown by Porsild and Cody (1980).

SCHEUCHZERIACEAE

Triglochin palustre L., Arrow-grass, *31526* (1) — This is an extension of the known distribution in northern District of Mackenzie, some 400 km eastwards from the east end of Great Bear Lake and northwards some 450 km from the east end of Great Slave Lake.

GRAMINEAE

Calamagrostis deschampsioides Trin., *31479* (1), *31482* (1), *31812* (11) — This is a littoral species of damp tundra in the Continental Northwest Territories. It is known from the Arctic Coast between the Mackenzie River Delta and Liverpool Bay, the Hudson Bay Coast, and a single inland station near the Keewatin-Mackenzie border.

Calamagrostis neglecta (Ehrh.) Gaertn., Mey. & Schreb., *31457* (1), *31826* (12) — These collections help to complete the knowledge of the distribution in northern District of Mackenzie as shown by Porsild and Cody (1980). The nearest previous collections are from south of Queen Maud Gulf, on southwestern Victoria Island, and about Great Bear Lake.

Deschampsia caespitosa (L.) Beauv., Tufted Hairgrass, *31452* (1), *31465* (1), *31472* (1), *31810* (11), *31880* (16), *31881* (16), *31886* (16) — These collections extend the known range in northern District of Mackenzie, eastwards from Coppermine and about Great Bear Lake and northwards about 300 km from sites in the interior of District of Mackenzie.

Poa alpigena L., Blue Grass, *31456* (1), *31468* (1), *31475* (1), *31882* (16) — The closest known sites in District of Mackenzie are about Great Bear and Great Slave lakes. There is, however, a site on southeastern Victoria Island.

Poa alpina L., Blue Grass, *31454* (1), *31480* (1) — This is an eastwards extension of the known range in northern District of Mackenzie, some 400 km from the east end of Great Bear Lake and northwards of some 450 km from the east end of Great Slave Lake and near the Keewatin-Mackenzie border.

Poa arctica R. Br., Arctic Blue Grass, *31759* (8), *31763* (8) — This is a wide-ranging circumpolar species. These collections help fill in the known distribution along the Arctic Coast as shown by Porsild and Cody (1980).

Puccinellia agrostoidea Th. Sor., Alkali-grass, *31839* (13) — This endemic of the western Canadian Arctic and Ellesmere Island is a non-littoral species of turfy tundra. The collection cited here is the most southerly found to date.

Puccinellia deschampsioides Th. Sor., Alkali-grass, *31467* (1), *31478* (1) — This species which was described from West Greenland, occurs on dry mildly alkaline or saline flats. The known occurrences across northern Canada are widely isolated and disjunct.

CYPERACEAE

Carex garberi Fern., Sedge, *31500* (1) — This is an extension of the known range in northern District of Mackenzie of some 400 km eastwards from Great Bear Lake and some 450 km northwards from the east end of Great Slave Lake.

Carex glareosa Wahlenb. var. *amphigena* Fern., Sedge, *31816* (11) — This is a seashore plant which, with the exception of a site on western Victoria Island, was not previously known from the area between Nicholson Island and Hudson Bay.

Carex nardina Fries var. *atriceps* Kuk., Sedge, *32024A* (32), *32025* (32) — This is an Amphi-Atlantic species. This collection helps complete the knowledge of the distribution between Dolphin and Union Strait, Great Bear Lake, north of the East Arm of Great Slave Lake, and central District of Keewatin as shown by Porsild and Cody (1980).

Carex tenuiflora Wahlenb., Sedge, *31706* (4) — This is an extension of the known range in northern District of Mackenzie of some 400 km eastwards from Great Bear Lake and 450 km northwards from the east end of Great Slave Lake and central District of Keewatin.

Carex vaginata Tausch., Sedge, *31498* (1) — This is an extension of the known range from sites on Coronation Gulf. It is the easternmost site yet known at this latitude in District of Mackenzie.

Eleocharis acicularis (L.) R. & S., Spike-Rush, *31697* (3) — This collection is from the most northeasterly site yet known in District of Mackenzie; to the west it is known from the vicinity of Coppermine and Great Bear Lake, to the south at Yellowknife on Great Slave Lake, and to the southeast in Central District of Keewatin.

Eriophorum russeolum Fries var. *albidum* Nyl., Cotton-Grass, *31794* (10) — Along the Arctic Coast, not previously known from the area between Queen Maud Gulf and the Mackenzie Grazing Preserve. To the south, the nearest known site is about 300 km.

Eriophorum vaginatum L., Cotton-Grass, *31504* (1), *31817* (11) — These collections help complete the knowledge of the distribution in northeastern District of Mackenzie as shown by Porsild and Cody (1980). They are intermediate between sites south of Queen Maud Gulf and south of Coronation Gulf.

JUNCACEAE

Luzula parviflora (Ehrh.) Desv., Wood Rush, *31856* (14), *31909* (20) — In the Continental Northwest Territories, these collections are intermediate between sites on Great Bear Lake and Franklin Lake south of Boothia Peninsula.

SALICACEAE

Salix brachycarpa Nutt. ssp. *brachycarpa*, Willow, *31948* (24) — This collection represents an extension of the known range in northern District of Mackenzie of about 400 km eastwards from the east end of Great Bear Lake.

Salix fullertonensis Schneid. (*S. brachycarpa* Nutt. ssp. *niphoclada* (Rydb.) Argus var. *fullertonensis* (Schneid.) Argus, Willow, *31899* (19), *31908* (20) — This species has its main range around Hudson Bay, with disjunct stations in northern District of Mackenzie (the dot inadvertently omitted on the map in Porsild and Cody (1980) and Bathurst Inlet.

Salix fuscescens Anders., Willow, *31806* (11), *31878* (16) — This Amphi-Beringian species was previously unknown along the Arctic Coast between Queen Maud Gulf and the west side of Franklin Bay; to the south it is known from a number of collections from the western part of District of Keewatin and eastern District of Mackenzie.

Salix lanata L. ssp. *richardsonii* (Hook.) Skvortsov, Willow, *31439* (1), *31912* (21) — These collections help complete the knowledge of the known distribution along the Arctic Coast as shown by Porsild and Cody (1980).

Salix planifolia Pursh ssp. *planifolia*, Willow, *31702* (4), *31807* (11), *31887* (17), *31895* (18) — These are the most northeasterly collections yet made in District of Mackenzie. They form an easterly extension of the known distribution in northern District of Mackenzie of some 400 km from Great Bear Lake sites, and about 175 km northward from a site in central eastern District of Mackenzie.

MYRICACEAE

Myrica gale L., Sweet Gale, *31933* (22) — This species is frequent about Great Bear and Great Slave Lakes and the area between them, but this collection which represents an extension of the known range of some 400 km, is from far beyond the black spruce bogs in which it is usually found.

BETULACEAE

Betula occidentalis Hook., Birch, *31969* (26) — Like the previous species, this represents an extension of the known range in northern District of Mackenzie of some 400 km eastwards from the east end of Great Bear Lake.

CARYOPHYLLACEAE

Minuartia biflora (L.) Schinzl. & Thell., Sandwort, *31731* (5), *31734* (5) — This is the most northeasterly site yet discovered in District of Mackenzie. The species was previously known in the vicinity of Coppermine, about Great Bear Lake, and near the Keewatin-Mackenzie border to the southeast.

Stellaria edwardsii R. Br., Chickweed, *31958* (24) — Previously unrecorded along the north coast of Continental Northwest Territories between Liverpool Bay and Spence Bay, but known to the north on Banks,

Victoria, and King William islands, and to the south around Great Bear and Great Slave lakes.

Stellaria longipes Goldie, Chickweed, *31570* (1) — In eastern District of Mackenzie this is an extension of the known range northward of about 275 km, but there is a collection from southeastern Victoria Island that Porsild (mss.) thought might represent a recent introduction.

RANUNCULACEAE

Anemone multifida Poir., Anemone, *31938* (22) — This is an extension of the known range into the barren lands of some 400 km eastwards from Great Bear Lake and northwards of some 450 km from the east end of Great Slave Lake.

Ranunculus hyperboreus Rottb., Buttercup, *31820* (11) — This is a circumpolar arctic-alpine species which was not previously known from the Bathurst Inlet region, but was known from the south shore of Coronation Gulf to the west and bear the Mackenzie-Keewatin border to the east.

Ranunculus sulphureus Sol., Buttercup, *31670* (2) — This is a circumpolar arctic-alpine species which was hitherto unknown in the Continental Northwest Territories east of the Mackenzie River.

CRUCIFERAE

Braya purpurascens (R. Br.) Bge., *31730* (5) — This is a circumpolar high-arctic species which was previously known in Continental Northwest Territories in the Mackenzie Mountains and near the Arctic Coast west of Dolphin and Union Strait. Numerous collections have been made on the arctic islands to the north.

SAXIFRAGACEAE

Saxifraga caespitosa L., Tufted Saxifrage, *31758* (7), *31863* (14) — Certainly expected but not previously collected in the Bathurst Inlet region.

ROSACEAE

Potentilla nivea L. ssp. *chamissonis* (Hultén) Hiit, Cinquefoil, *31721* (5), *31766* (8) — The collections cited here are from within the general range of the subspecies, but it has not previously been recorded from the Bathurst Inlet region. The nearest known sites in District of Mackenzie are in the vicinity of Coppermine and about 205 km to the south.

Potentilla nivea L. ssp. *hookeriana* (Lehm.) Hiit., Cinquefoil, *31545* (1), *31546* (1), *31719* (5), *31720* (5), *31981* (26) — These collections represent an extension of the known range eastwards from the vicinity of Coppermine, and are the most northeasterly yet recorded.

VIOLACEAE

Viola pallens (Banks) Brainerd, Violet, *31894* (17) —This is an extension of the known range into the barren grounds of some 550 km eastwards from the west side of Great Bear Lake and 400 km northwards from a site north of the East Arm of Great Slave Lake.

ERICACEAE

Oxycoccus microcarpus Turcz., Cranberry, *32028* (32) — The known distribution of this muskeg species which was previously known to extend just north of treeline, is now extended in the Northwest Territories some 400 km eastwards from Great Bear Lake and some 300 km northwards from sites north of the East Arm of Great Slave Lake.

PRIMULACEAE

Primula egaliksensis Wormskj., Primula, *31735* (5) — With this collection, the known range of *P. egaliksensis* in the Northwest Territories is extended eastwards some 200 km from Coppermine. This is the most northeasterly collection yet made in Continental Northwest Territories.

LENTIBULARIACEAE

Pinguicula villosa L., Butterwort, *31803* (10) — The known range of this tiny plant which often grows in association with *Oxycoccus microcarpus* on *Sphagnum* hummocks, is likewise extended into the barren grounds some 400 km eastwards from Great Bear Lake and northwards from sites north of the East Arm of Great Slave Lake.

COMPOSITAE

Erigeron compositus Pursh, Fleabane, *31984* (26) — This collection extends the known range in District of Mackenzie eastwards from the west end of Coronation Gulf and the east end of Great Bear Lake.

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Douzième inventaire des populations d'oiseaux marins dans les refuges de la Côte-Nord du golfe du Saint-Laurent

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Chapdelaine, Gilles, et Pierre Brousseau. 1984. Douzième inventaire des populations d'oiseaux marins dans les refuges de la Côte-Nord du golfe du Saint-Laurent. Canadian Field-Naturalist 98(2): 178–183.

Les résultats du douzième inventaire des oiseaux marins des refuges de la Côte-Nord du golfe du Saint-Laurent révèlent des changements appréciables parmi les espèces inventoriées. Parmi les phalacrocoracidés, le Cormoran à aigrettes a considérablement augmenté. Chez les laridés, nous avons observé des augmentations pour le Goéland argenté et la Mouette tridactyle. Le Goéland à bec cerclé a diminué à la suite du déplacement de la colonie de Betchouane à l'extérieur du refuge. Parmi les alcidés, la Marmette commune et le Macareux moine ont augmenté. Étant donné l'importance du Macareux moine de l'île aux Perroquets (Baie de Brador) et de l'augmentation enregistrée en 1982, nous discutons de la précision sur l'estimation de cette population.

Mots clés: oiseaux marins, population, refuges, golfe du Saint-Laurent, Phalacrocoracidae, Laridae, Alcidae.

The twelfth census of seabirds nesting in the Migratory Bird Sanctuaries of the North Shore of the Gulf of St. Lawrence showed noticeable changes for different species. Among phalacrocoracids, Double-crested Cormorant increased markedly. Among larids, Herring Gull and Black-legged Kittiwake increased. Ring-billed Gull diminished because of movement from the Betchouane sanctuary to sites outside the refuge. Of the alcids, Common Murre and Atlantic Puffin increased. Because puffins at Perroquet Island (Bradore Bay), a major nesting site, increased markedly, we discuss the precision of that estimate.

Key Words: seabirds, population, sanctuaries, Gulf of St. Lawrence, Phalacrocoracidae, Laridae, Alcidae.

Depuis 1925, le Service canadien de la faune réalise des inventaires d'oiseaux marins dans les refuges d'oiseaux migrateurs de la Côte-Nord du golfe du Saint-Laurent (Figure 1) (Lewis 1925, 1931, 1937, 1942; Hewitt 1950; Tener 1951; Lemieux 1956; Moisan 1962; Moisan et Fyfe 1967; Nettleship et Lock 1973; Chapdelaine 1980). Le but de ces inventaires de rappel est de mesurer les changements au sein des différentes populations d'oiseaux marins des refuges.

Un des problèmes majeurs des inventaires de rappel est l'uniformisation des méthodes. À cet effet, nous reconnaissons deux approches différentes correspondant aux périodes de 1925 à 1965 et de 1972 à 1982 respectivement. Depuis 1972, les recenseurs ont concentré leurs efforts pour utiliser les mêmes techniques d'inventaires et les mêmes colonies-témoins. Tous les détails relatifs à ces inventaires (paramètres météorologiques, méthode de calcul des estimations, cartographie des colonies) sont consignées dans Nettleship, Chapdelaine et Brousseau et Chapdelaine (manuscrits non publiés). À notre avis, ces informations détaillées nous permettent de comparer avec moins d'ambiguité les résultats de 1982 avec ceux de 1977 et de 1972, sans qu'ils soient pour autant exempts de certaines imprécisions.

Méthodes

Nous avons résumé les méthodes d'inventaire d'après les familles d'oiseaux marins représentés dans les 8 refuges*. Ceci inclut le refuge des îles aux Perroquets sanctionné en 1982.

GAVIIDÉS: Nous avons dénombré systématiquement les nids de Huart à gorge rousse** autour des étangs des îles de chaque refuge.

HYDROBATIDÉS: Compte tenu des faibles dimensions des colonies de Pétrel cul-blanc, nous avons effectué des dénombrements complets des terriers actifs (terriers avec 1 oeuf ou 1 adulte présent, terriers fraîchement labourés d'où émane une forte odeur).

ANATIDÉS: Nous avons estimé les populations d'Eider à duvet selon les méthodes suivantes: (1) dénombrements complets des nids lorsque le temps et la dimension des îles le permettaient, (2) système de quadrats permettant d'obtenir une densité moyenne (couples/ha) extrapolée à la superficie occupée par l'ensemble de la colonie pour les îles de grande dimension, (3) dans les refuges où on retrouve un très grand nombre d'îles (e.g. Watshishu, Baie des Loups), nous avons dénombré tous les nids sur au moins 28 % (53 % pour Baie des Loups) de la superficie des îles de

*Le refuge de Saint-Augustin n'a pu être inventorié à la suite mauvaises conditions météorologiques et de certaines contraintes logistiques.

**Les noms scientifiques des espèces d'oiseaux apparaissent au tableau 1.

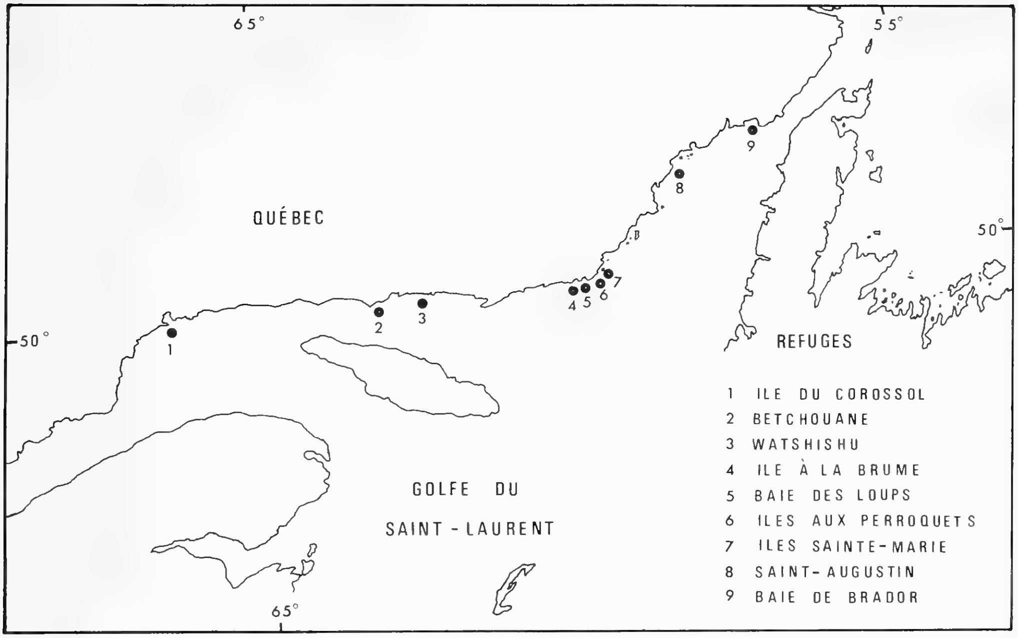

FIGURE 1. Localisation des refuges de la Côte-Nord du golfe du Saint-Laurent.

chaque refuge et calculé une densité moyenne extrapolée à la superficie totale de toutes les îles du refuge.

PHALACROCORACIDÉS: Nous avons dénombré systématiquement tous les nids du Grand Cormoran et du Cormoran à aigrettes. Dans le refuge de l'île du Corossol, les Cormorans à aigrettes nichent dans le faîte des épinettes. Le dénombrement complet s'est effectué à partir des points d'observation de l'île.

LARIDÉS: Les techniques d'inventaire variaient selon les espèces, la nature des sites de nidification et la dimension des colonies: (1) dénombrements complets des nids: Goéland argenté, Goéland à bec cerclé, Mouette tridactyle, Sterne commune, Sterne arctique, (2) sélection de colonies-témoins où le nombre de nids (Np) et le nombre d'adultes (Ni) sont déterminés, puis application du facteur de conversion K = Np/Ni pour estimer le nombre de couples dans les colonies où nous avons dénombré seulement les adultes présents (Goéland argenté, Sterne commune et Sterne arctique, (3) dénombrement des adultes (Goéland à manteau noir). Étant donné qu'il est difficile et onéreux de différencier la Sterne commune de la Sterne arctique dans les colonies mixtes, nous avons regroupé les résultats pour ces deux espèces.

ALCIDÉS: Nous avons effectué des dénombrements complets d'oeufs de Marmette commune pour plus de 60% de la population estimée. Nous avons utilisé la méthode du facteur K = Np/Ni pour estimer 2 colonies du refuge des îles Sainte-Marie (40% du nombre total de Marmette commune de ce refuge). Nous avons utilisé les techniques d'inventaire suivantes pour le Gode: (1) dans les refuges de l'île du Corossol, de Betchouane et de l'île à la Brume, nous avons dénombré les oiseaux adultes aux colonies, (2) dans le refuge de Baie des Loups, nous avons estimé 15% de la population d'après un dénombrement complet des oeufs et 85% selon la méthode du facteur de conversion, (3) dans les refuges des îles Sainte-Marie et des îles aux Perroquets, nous avons dénombré systématiquement tous les oeufs, (4) dans le refuge de la Baie de Brador, nous avons dénombré tous les oeufs à l'intérieur d'une superficie de 2 800 m^2 (28 parcelles-échantillons de 100 m^2. Par la suite, nous avons extrapolé nos décomptes d'oeufs des parcelles-échantillons à la superficie (13 280 m^2) de l'habitat typique du Gode dans ce refuge. Les populations de Guillemot noir ont été estimées à partir des dénombrements d'adultes autour des îles. Les colonies de Macareux moine du refuge de Betchouane, des îles Sainte-Marie et des îles aux Perroquets ont fait l'objet de dénombrements systématiques de terriers occupés.

Dans le refuge de Baie des Loups, nous avons utilisé la méthode des quadrats alignés (Nettleship 1976) à l'île des Loups où on retrouve 10% de la population totale du refuge. Sur l'île Blacklands où se retrouvent 86% de la population, nous avons employé la méthode du facteur de conversion et ailleurs dans le refuge un dénombrement complet des terriers occupés. Dans le refuge de Baie de Brador (l'île aux Perroquets et l'île Greenly), nous avons utilisé la méthode des quadrats alignés à l'intérieur desquels nous avons dénombré tous les terriers occupés et inoccupés.

Résultats

Au tableau 1, nous remarquons une augmentation du nombre total d'oiseaux de l'ordre de 40% entre 1977 et 1982. Parmi les 15 espèces inventoriées, 8 espèces ont montré des augmentations, 2 se sont maintenues et 1 ne peut être comparée en raison de l'absence d'estimation en 1977.

Dans le *Refuge de l'île du Corossol* (visité les 4 et 5 juin), nous avons noté d'importantes augmentations pour le Cormoran à aigrettes, les Goélands à manteau noir et argenté et la Mouette tridactyle. Ces espèces montrent non seulement des augmentations dans les colonies traditionnelles, mais elles occupent de nouveaux espaces sur l'île, tendant à modifier la physionomie de l'habitat. L'expansion de la colonie de Cormoran à aigrettes a provoqué la détérioration de certains secteurs de la forêt coniférienne et de nombreux sites de bois chablis. Ces éclaircies sont à leur tour occupées par les Goélands à manteau noir et argenté, espèces inféodées à de tels milieux. L'augmentation apparente du Gode et du Guillemot noir est plus difficile à confirmer à cause de la méthode d'inventaire qui se révèle peu exhaustive. Les alcidés manifestent des rythmes journaliers et saisonniers, ce qui nécessite des séances d'observation prolongées pour connaître l'amplitude des variations (Cairns 1979). Dans le cadre du présent travail, il est impossible d'effectuer de telles séances.

Dans le *Refuge de Betchouane* (visité le 7 juin), nous avons enregistré des hausses pour l'Eider à duvet, le Goéland argenté, la Mouette tridactyle, le Gode et le Macareux moine. Le Goéland à manteau noir a diminué alors que le Goéland à bec cerclé était absent du refuge. Signalons que cette espèce est reconnue pour ses déplacements périodiques d'un endroit à un autre ce qui n'implique pas nécessairement la disparition de cette colonie (Chapdelaine et Bourget 1981).

Dans le *Refuge de Watshishu* (visité le 7 juin), nous avons noté l'augmentation du Cormoran à aigrettes, des Goélands à manteau noir, argenté et à bec cerclé. L'Eider à duvet est apparu moins abondant qu'en 1977 et il en est de même pour le Gode et le Guillemot noir. Toutefois, ce refuge contribue très peu à influencer le total comparatif de 1977 *vs* 1982 étant donné la faible représentation des différentes espèces qui s'y trouvent.

Nous avons visité le *Refuge de l'île à la Brume* le 11 juin. Des augmentations ont été signalées pour le Huart à gorge rousse, les Goélands à manteau noir et à bec cerclé, les Sternes commune et arctique et le Guillemot noir. L'Eider à duvet a diminué tandis que le Gode est demeuré à peu près stable. Mis à part l'intérêt particulier que représente la nidification de la Sterne caspienne sur l'île à la Brume, ce refuge est très peu représentatif de l'abondance et de la diversité des espèces d'oiseaux marins que l'on retrouve le long de la Côte-Nord.

Le *Refuge de Baie des Loups* (visité les 16, 17 et 18 juin) est fréquenté par onze espèces, ce qui en fait le plus diversifié après celui des îles Sainte-Marie. Le Goéland argenté, les Sternes commune et arctique, le Guillemot noir et le Macareux moine ont connu des augmentations. L'Eider à duvet, le Goéland à manteau noir, le Gode et la Marmette commune ont considérablement diminué et le Cormoran à aigrettes ne niche plus dans ce refuge. L'augmentation du nombre total d'oiseaux à l'intérieur du refuge est attribuable en grande partie au Macareux moine dont les effectifs ont doublé.

Nous avons réalisé l'inventaire du *Refuge des îles Sainte-Marie* du 22 au 25 juin. Le Cormoran à aigrettes, les Goélands à manteau noir et argenté, la Mouette tridactyle, la Marmette commune et le Macareux moine ont augmenté. Les populations de Sternes commune et arctique et de Gode sont demeurées à peu près stables. C'est dans ce refuge que nous avons trouvé le plus grand nombre de Pétrel cul-blanc, soit 52 couples.

Dans le *Refuge de la Baie de Brador* (visité les 29 et 30 juin), nous avons observé une augmentation de l'ordre de 88% de la population de Macareux moine. Quant à la population de Gode, elle aurait sensiblement diminué.

Nous avons inventorié le *Refuge des îles aux Perroquets* les 19, 20 et 25 juin. Étant donné que c'est la première fois que ce groupe d'îles (5 îles) figure dans le programme d'inventaire quinquennal des refuges de la Côte-Nord, nous ne pouvons pas établir de comparaison avec 1977. Il s'agit d'un site très important puisqu'en termes de diversité, onze espèces d'oiseaux marins y nichent, dont 86% sont représentées par les alcidés.

Discussion

L'inventaire quinquennal des refuges d'oiseaux marins de la Côte-Nord du golfe du Saint-Laurent nous permet de connaître les tendances des popula-

TABLEAU I. Inventaire des Oiseaux marins (nombre d'individus) dans les refuges de la Côte-Nord du golfe du Saint-Laurent en 1977 et 1982

	Ile du Corossol		Betchouane		Watshishu		Ile à la Brume		Baie des Loups		Iles Sainte-Marie		Baie de Brador		Totaux		Iles aux Perroquets	Grand Total
Espèces	1977	1982	1977	1982	1977	1982	1977	1982	1977	1982	1977	1982	1977	1982	1977 vs	1982	1982	1982
Huart à gorge rousse *Gavia stellata*							4	10	6	10	28	18			38	38	26	64
Pétrel cul-blanc *Oceanodroma leucorhoa*									+	88		104			+	192	42	234
Grand Cormoran *Phalacrocorax carbo*											214	134			214	134		134
Cormoran à aigrettes *Phalacrocorax auritus*	216	700			89	277			16		122	376			443	1 353		1 353
Eider à duvet *Somateria mollissima*	292	246	8	30	296	158	352	144	826	562	340	274			2 114	1 414	304	1 718
Goéland à manteau noir *Larus marinus*	66	259	75	31	110	162	26	65	535	238	524	832	2	12	1 338	1 599	69	1 668
Goéland argenté *Larus argentatus*	2 940	8 218	302	908	277	329	260	154	424	1 130	540	2 434			4 743	13 173	314	13 487
Goéland à bec cerclé *Larus delawarensis*			1 038	1	2	24	122	178							1 162	203	188	391
Mouette tridactyle *Rissa tridactyla*	3 466	7 334	12	24							48	148			3 526	7 506		7 506
Sterne commune et arctique *Sterna hirundo* et *S. paradisaea*				10	620	680	102	330		49	88	94			810	1 163	112	1 275
Sterne caspienne *Sterna caspia*							3	7							3	7		7
Gode *Alca torda*	187	315	22	55	9	4	7	8	1 190	406	1 192	1 216	452	376	3 059	2 380	1 192	3 572
Marmette commune *Uria aalge*	3	21							246	34	8 986	11 850			9 235	11 905	2 710	14 615
Guillemot noir *Cepphus grylle*	24	65		1	46	34	47	74	47	100	342	176			506	450	23	473
Macareux moine *Fratercula arctica*			88	182					5 652	11 646	1 546	2 942	7 430	13 046	14 716	27 816	2 650	30 466
TOTAL	7 194	17 158	1 545	1 242	1 449	1 668	923	970	8 942	14 263	13 970	20 598	7 884	13 434	41 907	69 333	7 630	76 963

tions pour la grande majorité des espèces. Toutefois, la précision de ces changements est difficile à déterminer en raison des techniques d'inventaire qui exigent parfois des sessions d'observation prolongées. Dans cette optique, le cas des alcidés est tout particulièrement problématique lorsque nous dénombrons les individus et utilisons un facteur de conversion pour obtenir le nombre de couples. Étant donné que l'inventaire des oiseaux marins de la Côte-Nord consiste en une seule visite aux colonies, il nous est impossible d'effectuer une série de dénombrements journaliers qui permettraient de mesurer la précision sur l'estimation du nombre d'individus observés (Lloyd 1975; Cairns 1979; Stowe 1982; Hanssen 1982). De plus, la visite de 9 refuges échelonnés sur plus de 600 kilomètres de côte ne permet pas aux recenseurs de synchroniser leurs visites avec la phénologie de nidification de toutes les espèces occupant un refuge. Alors que les visites semblent correspondre assez bien avec la période où un nombre maximum d'Eider à duvet, de Cormoran à aigrettes et de plusieurs laridés ont pondu dans les refuges de l'île du Corossol, Betchouane, Watshishu, île à la Brume et Baie des Loups, les alcidés et les sternes n'en sont qu'au début de la ponte dans ces mêmes refuges. À partir des îles aux Perroquets (nouveau refuge) jusqu'à la Baie de Brador, nous nous retrouvons probablement à la bonne période pour inventorier les alcidés et les sternes, mais il est déjà trop tard pour les Eiders à duvet et certaines espèces de laridés qui ont déjà atteint le stade de l'éclosion.

Même à l'aide de techniques plus complexes, il n'est pas facile d'établir avec précision la tendance d'une population. Prenons le cas du Macareux moine de l'île aux Perroquets (Refuge de la Baie de Brador). À cet endroit, une série de quadrats alignés et espacés également entre eux traversent l'île de part et d'autre. Cette méthode qui correspond à un échantillonnage systématique (Norton-Griffiths 1975; Caughley 1977) nous permet à la fois de cartographier la distribution de la colonie et d'estimer le nombre total d'oiseaux. Au tableau 2, nous présentons les différents paramètres statistiques qui nous ont permis de détecter les changements intervenus dans la colonie. Entre 1972 et 1977, la diminution était caractérisée par la réduction de la superficie de la colonie et par une légère diminution du nombre de terriers occupés/100m². Entre 1977 et 1982, l'augmentation s'est manifestée par un accroissement de la superficie de la colonie et du nombre moyen de terriers occupés/100 m². Malgré toutes les indications d'une tendance à la hausse, nous devons être circonspects quant à la précision réelle de l'augmentation entre 1977 et 1982. Car à partir d'un programme d'inventaires de rappel tenu annuellement dans certaines colonies d'Écosse, Harris et Murray (1981) ont démontré qu'à cause des variations interannuelles très élevées des estimations obtenues d'après la méthode de l'échantillonnage systématique (variations dues en grande partie à une fraction de la population nichant sporadiquement même si elle est en âge adulte), il est nécessaire d'obtenir une séquence de plusieurs années avant de détecter une tendance certaine. Il ajoute qu'une variation annuelle de ± 30 % ne nous permet pas de préciser la tendance. Or, entre 1977 et 1982, nous n'avons pas effectué d'inventaires pouvant préciser l'ordre de grandeur d'une telle variation.

Les causes d'augmentation, de diminution et de stabilisation des espèces recensées dans les refuges ne peuvent pas être mises en évidence sans études biologiques détaillées et spécifiques visant à décrire les mécanismes de cause à effet impliqués dans la dynamique des populations d'oiseaux. De telles études dépassent largement l'objectif principal de notre pro-

TABLEAU 2. Estimation de la population totale de Macareux moine de l'île aux Perroquets (Baie de Brador) en 1972, 1977 et 1982 d'après un échantillonnage en transects-quadrats espacés systématiquement.

Année	Superficie de la colonie (m²)	N	n	Σy	$\bar{y}$	S^2	$\hat{Y}$	Limite de confiance de 95 % (%)
1972	83 087	831	192	1 069	5,61	26,47	4 661	± 541 (± 11,6)
1977	65 612	656	143	675	4,69	19,65	3 076	± 430 (± 13,9)
1982	77 500	775	159	1 197	7,48	59,17	5 797	± 846 (± 14,6)

N = Nombre de quadrats de 100 m² dans la colonie

n = Nombre de quadrats de 100 m² échantillonnés avec des terriers occupés

Σy = Somme des terriers occupés pour l'échantillon n

$$\bar{y} = \frac{\Sigma y}{n}$$

$$\hat{Y} = N\bar{y}$$

$$S^2 = \left[\left(\frac{N(N-n)}{n}\right)\frac{1}{n-1}\left(\Sigma y^2 - \frac{(\Sigma y)^2}{n}\right)\right]$$ d'après Cochran 1979.

gramme d'inventaires actuel bien qu'elles soient souhaitables.

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Habitat Use, Movements and Grouping Behaviour of Woodland Caribou, *Rangifer tarandus caribou,* in Southeastern Manitoba

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The Aikens Lake Woodland Caribou (*Rangifer tarandus caribou*) herd of 30 to 40 individuals was studied from March 1975 to April 1977. Caribou were monitored by aerial surveys and ground searches during months with snow cover and by ground searches only during snow-free months. Two Caribou were radio-collared. Caribou and Caribou tracks were seen relatively more often in mature coniferous upland habitat than in other available habitats, except during October, December and January when semi-open and open bogs were used more. The increased use of bogs coincided with a seasonal change in diet and onset of the rut. Favoured use of bogs continued until mid-February when snow cover thickness and hardness restricted foraging. Caribou then switched back to sites with more favourable snow-cover conditions in mature coniferous uplands, especially rocky ridges with Jack Pine (*Pinus banksiana*). Caribou did not migrate. Seasonal herd ranges consisted largely of overlapping individual ranges and varied from 100 to 180 km^2 in early spring, 175 to 190 km^2 in late spring and summer, 115 km^2 in autumn and 95 to 140 km^2 in winter. Mean group size was 5.8 in early spring, 1.2 in late spring and summer, 6.2 in autumn and 5.5 in winter.

Key Words: Caribou, habitat use, movements, behaviour.

Woodland Caribou (*Rangifer tarandus caribou*) have been studied in mountainous (Moisan 1958; Edwards and Ritcey 1959; Bergerud 1973; Freddy 1979; Oosenburg and Theberge 1980) and open habitats (Bergerud 1974; Dauphiné et al. 1975), but information on Caribou in the boreal forest is limited (Stardom 1975; Shoesmith and Storey 1977; Fuller and Keith 1981). From March 1975 to April 1977 we studied Woodland Caribou in southeastern Manitoba to determine seasonal patterns of habitat use, movements and grouping behaviour, and to test Stardom's (1975) threshold values for Woodland Caribou tolerance of snow cover in open bogs.

Study Area

The study area was 1600 km^2 surrounding the University of Manitoba Taiga Biological Station (51°02′N; 95°20′W) near Wallace Lake (Figure 1). The study area is characterized by ridges of Precambrian Shield oriented northwest-southeasterly at 300 to 350 m above sea level, and drainage is westward to Lake Winnipeg.

Uplands were dominated by mature stands of Jack Pine (*Pinus banksiana*), White Spruce (*Picea glauca*) and Black Spruce (*Picea mariana*), with dense ground lichens (*Cladonia* spp.) on rocky ridges with Jack Pine. Sub-dominant species included Balsam Fir (*Abies balsamea*), Paper Birch (*Betula papyrifera*), Trembling Aspen (*Populus tremuloides*) and Balsam Poplar (*Populus balsamifera*). Lowlands varied from dense Black Spruce bogs to open Sedge (*Carex* spp.) tussock bogs with scattered Tamarack (*Larix laricina*) and Black Spruce supporting arboreal lichens (*Alectoria* sp., *Evernia* sp., *Parmelia* sp., *Ramalina* sp., *Usnea* sp.). Other vegetation communities were immature Jack Pine (less than 15 m high) and mixedwood and hardwood stands. For a more detailed description of vegetation communities and their distribution see Darby (1979).

During 1976, fires destroyed 40 km^2 of mature forest southeast of Aikens Lake, but most lowland sites were not burned. Trapping and tourism occurred throughout the study area, but road access and logging occurred only in the southwest.

The study area has a boreal continental climate and lies within a dry subhumid moisture region. Mean monthly temperature is 19° C for July and – 21° C for January (Woo et al. 1977). Annual precipitation averages 423 mm of which 40% falls as snow (152 cm) between 1 October and 30 April. Climatic conditions and snow accumulation were near average during 1975-1976. Rainfall during the spring and summer of 1976 was less than average, as was snowfall (135 cm) during the following winter.

Caribou in the study area are referred to as the Aikens Lake herd. We inventoried them in late March 1976 and 1977 by aerial surveys and then checked the estimates by ground searches. The Aikens Lake herd appeared to number 30-40 individuals at those times. The closest known herds of Caribou were 50-100 km away; they were not observed to interact with Aikens Lake Caribou.

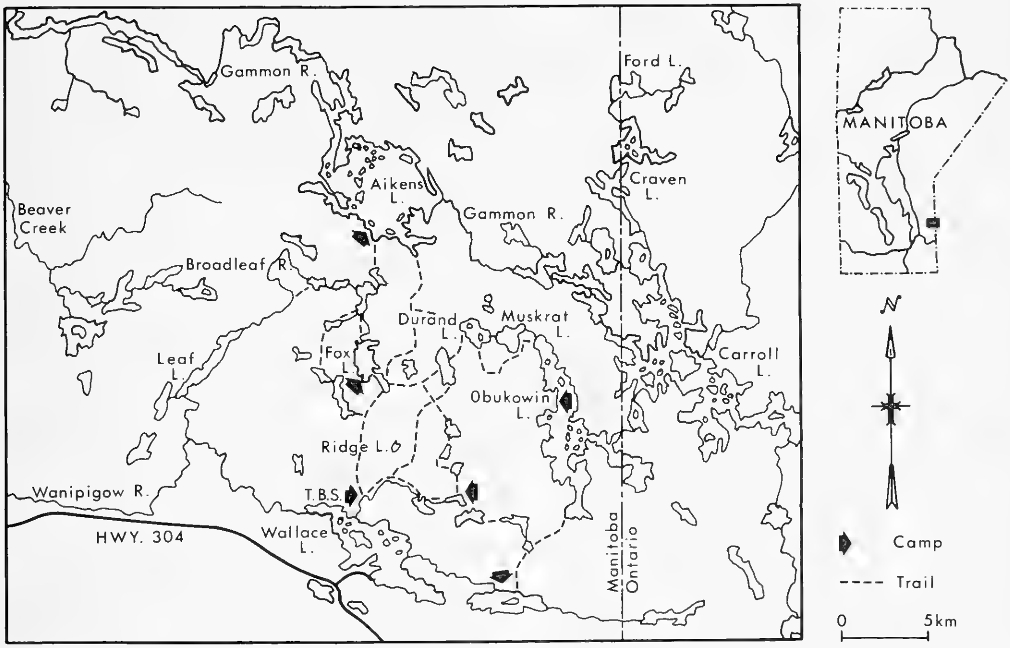

FIGURE 1. The Aikens Lake study area.

Methods

Data on seasonal changes in habitat use, movements and group size of Caribou were obtained during 13 flights (36 h) in a Piper PA–12 aircraft, and 1017 person-days of ground investigation involving more than 10000 km of travel by foot, canoe and snowmobile. Aerial surveys were flown once a month during March and April 1975, December through April 1976 and December through March 1977, with an additional survey flown in March of both 1976 and 1977. During each survey the aircraft flew at 145 km/h, 125 m above ground level, along 11 east-west transects 30 km long, 2.5 km apart. Two observers, one on either side of the aircraft, recorded all observations of Caribou, Caribou tracks and feeding craters, and the habitat type(s) for each observation. Fresh tracks were followed and back-tracked whenever possible. The return trip from each survey was used to check areas peripheral to the transects. Ground investigations involved tracking Caribou during all seasons. We recorded all observations of Caribou, Caribou tracks and pellet groups and the corresponding habitat type(s). Travel was facilitated by a system of trails established throughout the study area and by caching boats and canoes on water systems. Field investigations were not conducted during spring break-up (20 April to 10 May).

Two adult Caribou were radio-collared during the study. Radio-collars containing AVM model SB–2 transmitters were attached to swimming Caribou and relocations were obtained on foot, from tree towers and by aircraft, using an AVM model LA-12 portable receiver and 4-element Yagi antenna(e).

Habitat use by Caribou was determined from records of habitat type for each observation of Caribou and Caribou tracks. Radio-tracking data were not used for habitat determination because the error polygons of intersecting bearings contained two or more habitat types. We excluded observations in which Caribou appeared to be aware of the observer's presence. We also excluded habitat records for radio-collared Caribou when sightings occurred more than twice in the same day, in order to maintain independence of observations. One track observation constituted the trail of one or more Caribou; where tracks were followed for some distance, each 0.5 km segment was recorded as one track observation. Thus, two or more habitat types often corresponded to one track observation, and sometimes to one visual sighting. For the purpose of recording habitat data, lowlands

were categorized as semi-open and open bog, heavily treed bog, and lakes including the land within 50 m of the shore. Upland categories were mature coniferous forest, mixedwood and deciduous forest, immature Jack Pine, and burns less than one-year old. Availability of these types was determined from forest cover maps of the Manitoba government as a percentage of a 720 km^2 area encompassing the Caribou seasonal ranges. Caribou use of islands during late spring and summer was investigated by searching most islands in lakes and rivers in the study area for Caribou or Caribou tracks and pellet groups.

Seasonal ranges of the herd were determined by mapping all observations of Caribou, Caribou tracks and pellet groups, and radio-tracking locations. Seasonal range sizes were estimated by plotting and joining perimeter observations to form minimum convex polygons (Mohr 1947). Calendar dates of seasonal change were used except for early spring (21 March to 30 April) and late spring and summer (1 May to 21 September). Mean group size for each season was determined from visual observations and from tracking records where Caribou fanned out while crossing open areas of snow, or sand and mud.

Stardom's (1975) threshold values for Woodland Caribou tolerance of snow cover thickness (65 cm), maximum hardness (400 g cm^{-2}) and maximum density (0.18 to 0.24 g cm^{-3}) in open bogs were evaluated by testing the hypothesis that Caribou show no observable change in their use of semi-open and open bogs when threshold values are exceeded. Maximum hardness is the maximum average hardness recorded for any layer in a snow profile, and maximum density is the maximum average density for any layer (Stardom, personal communication). Data on snow cover thickness, hardness and density were collected following the methodology of Klein et al. (1950) at five locations in three habitat types in the Caribou winter range: one in semi-open bog and one in open bog; two on Jack Pine-rock ridge; and one on lake ice.

Results

Habitat Use

Observations of Caribou using a specific habitat type during a specific month totalled 719, based on an average 1.4 habitat types recorded for each of 48 visual sightings of one or more Caribou, and 482 tracking records. During both years of study the Aikens Lake herd occupied an area of mature coniferous uplands dissected by semi-open and open bogs. Caribou used mature coniferous uplands more than any other habitat type except during October, December and January when semi-open and open bogs were used more frequently (Table 1). Most of the mature upland forest was a mosaic of stands of Jack Pine, Jack Pine-Black Spruce-White Spruce, Black Spruce-Feather Moss (*Dicranum* sp., *Pleurozium schreberi*) and White Spruce-Balsam Fir-Paper Birch. Caribou selected areas of Jack Pine and Jack Pine-spruce. Within favoured sites, lush stands of ground lichens and ericoids (*Arctostaphylus uva-ursi, Chimaphila umbellata, Pyrola* spp., *Vaccinium myrtilloides*) were established under relatively open canopies of Jack Pine.

During early spring Caribou fed on terricolous and saxicolous lichens (*Cladonia* spp. and *Parmelia* spp.,

TABLE 1. Monthly use of habitat types by Aikens Lake Caribou from March 1975 to April 1977.

Habitat type	Percentage of Observations													
	Jan. (78)[a]	Feb. (155)	Mar. (129)	Apr. (37)	May (13)	Jun. (52)	Jul. (81)	Aug. (51)	Sep. (14)	Oct. (53)	Nov. (21)	Dec. (30)	Mean	Percentage available
LOWLANDS														
Semi-open and open bog	35	31	9	17	—	4	5	6	22	40	24	37	19	3
Heavily-treed bog	11	11	5	9	8	4	2	27	7	11	24	17	11	13
Lake	22	18	16	31	23	25	36	20	21	11	14	20	22	13
Total	68	60	30	57	31	33	43	53	50	62	62	74	52	29
UPLANDS														
Mature coniferous	31	36	69	43	46	59	42	47	43	32	38	23	42	28
Mixedwood and deciduous	—	—	—	—	8	6	10	—	7	6	—	—	3	10
Immature Jack Pine	—	—	—	—	15	2	5	—	—	—	—	—	2	29
Burns < 1 year old	1	4	1	—	—	—	—	—	—	—	—	3	1	4
Total	32	40	70	43	69	67	57	47	50	38	38	26	48	71

[a]Number of records of Caribou using a specific habitat type.

respectively) exposed by sublimation of snow in old feeding craters and clearings on Jack Pine-rock ridges, south-facing slopes and lakeshores. They also fed on the tips of willow (*Salix* sp.) and alder (*Alnus* sp.) twigs. In April sightings of Caribou and Caribou tracks were relatively numerous on mature coniferous uplands and lake ice (Table 1). During late spring and summer Caribou were observed feeding on ground forbs, deciduous foliage and arboreal and ground lichens, and they used a greater diversity of habitat types (Table 1).

Caribou calved in early May. Surveillance of islands and lakeshores revealed at least six Caribou using lakes frequently during late spring and summer of 1975: one cow-calf pair, two single cows (calves not observed if present), and two bulls. During the same period in 1976, at least three cow-calf pairs and two bulls were known to use islands and lakeshores frequently. Excursions into mainland portions of the late spring-summer range showed that many Caribou were still using mainland habitats.

In early autumn Caribou aggregated near semi-open and open bogs; this coincided with the dormancy of ground forbs and leafy browse, and with onset of the rut. Caribou fed on ground lichens, arboreal lichens, sedges and bog ericoids (*Andromeda glaucophylla, Chamaedaphne calyculata, Kalmia polifolia, Ledum groenlandicum*) at that time. The intensive use of bogs continued until snow restricted travel in mid-February; Caribou then used feeding craters on Jack Pine-rock ridges where they fed on *Cladonia* sp. and *Vaccinium myrtilloides*. Throughout winter Caribou used frozen lakes for travel, escape habitat and craters for drinking overflow water. Loafing on lakes was only common in late winter.

During most of each winter snow cover was thickest in semi-open and open bogs, less on Jack Pine-rock ridges and least on lake ice (Figure 2). Until mid-February maximum hardness values of snow cover on lakes were usually greater than in other habitats. Mean density values did not appear to bear any relationship to snow cover thickness, time, habitat or Caribou behaviour, and are not reported here. Until February, thickness and maximum hardness values of snow in semi-open and open bogs were less than Stardom's (1975) respective tolerance thresholds of 65 cm and 400 g cm^{-2} (Log_{10} = 2.602). After 1 February 1976 and 24 February 1977 either or both of these thresholds was often exceeded (Figure 2). Caribou showed a change in their use of semi-open and open bogs by switching most of their feeding activity to Jack Pine-rock ridges in mature coniferous stands for the rest of

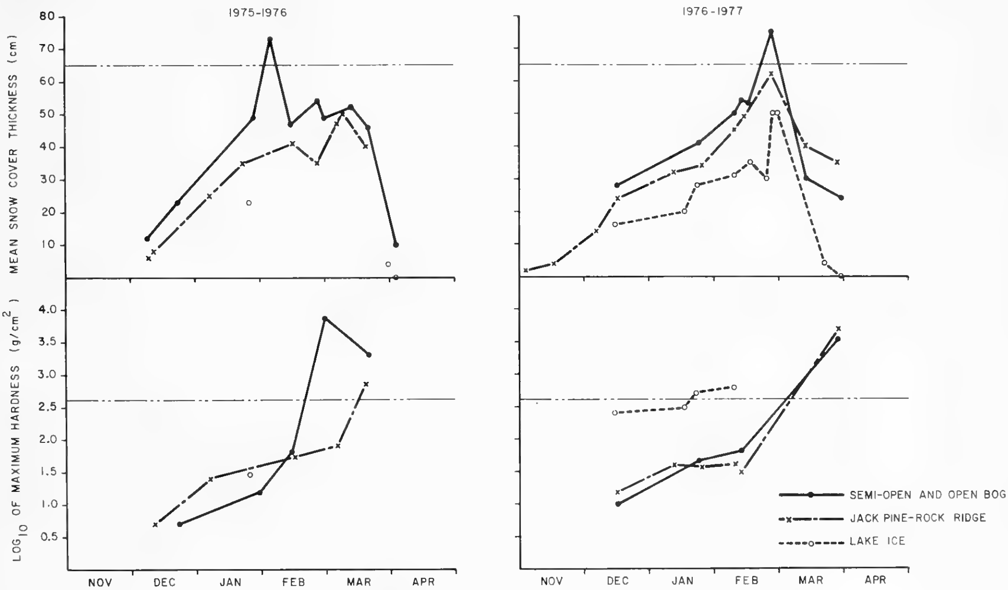

FIGURE 2. Summary of snowcover data for three habitats in the wintering range of Aikens Lake Caribou, 1975–1977. The horizontal double-dashed lines represent tolerance thresholds in semi-open and open bogs determined for Aikens Lake Caribou by Stardom (1975).

the winter (Table 1). They continued to cross semi-open and open bogs, especially in February, but they generally did so at narrow locations and in single file.

Seasonal Movements of Radio-collared Caribou

A total of 132 radio-tracking locations (n) were obtained for the two adult Caribou. An additional 15 radio-tracking locations resulted in the Caribou being sighted, so they were classed as visual sightings. Seasonal ranges of the two individuals were largely overlapping.

An 8-year-old female was radio-tracked from 19 May 1976 to 15 March 1977. During late spring and summer she occupied an area of 28 km^2 (n = 30) spanning Obukowin Lake (Figure 1). In late September she moved 7 km west to an area of open bogs occupied by Caribou. She expanded her range to 56 km^2 (n = 31) during autumn. During winter she occupied at least 34 km^2 (n = 7). On 15 March 1977 she was killed by wolves. During late spring, summer and autumn 61 radio receptions were obtained for the female during 73 attempts (84%), but in winter receptions fell to 7 of 24 attempts (29%) due to transmitter malfunction.

An adult male was radio-collared on 17 July 1976 after being frequently observed along the shore of Aikens Lake, and he was radio-tracked until 15 November 1976 when radio contact ceased. During summer the bull usually occupied 10 km^2 (n = 57) exhibiting very sedentary and habitual behaviour. He alternately used two areas of lakeshore on Aikens Lake, 5 km apart, for several days at a time. In each area he repeatedly used specific beds in or near favoured feeding sites. On three occasions, four to six weeks apart, he travelled south of Aikens Lake for one to three days. Radio-contact was lost at those times. His autumn range comprised at least 53 km^2 (n = 22); it included areas he was known to frequent in summer plus an area of open bogs south of Aikens Lake. During summer 57 radio receptions were obtained for the male during 62 attempts (92%), but in autumn only 22 receptions were obtained during 37 attempts (59%).

Seasonal Movements of the Herd

We used 738 pieces of evidence of Caribou presence recorded from March 1975 to April 1977 to estimate seasonal herd ranges: 49 visual sightings of one or more Caribou, 132 radio-tracking locations, 510 track observations, and 47 observations of pellet groups. Caribou did not migrate. Seasonal herd ranges were largely overlapping and consisted mainly of overlapping individual ranges (Table 2). For detailed maps of the ranges see Darby (1979).

During late spring and summer some Caribou were known to disperse beyond limits of the estimated herd range (one in 1975 and five in 1976), at least temporarily, but they could not be followed. Extensive ground searches of portions of the study area peripheral to the estimated herd range did not reveal evidence of Caribou presence.

TABLE 2. Seasonal changes in herd range size for Aikens Lake Caribou

Season	Herd Range Size (km^2)		
	1975-1976	1976-1977	1977-1978
Early spring 21 March-30 April	— (16)[a,b]	180 (65)	100 (42)
Late spring-summer 1 May-21 September	190 (61)	175 (203)	
Autumn 21 September-21 December	— (11)[b]	115 (126)	
Winter 21 December-21 March	95 (89)	140 (125)	

[a]Number of observations including visual sightings, radio-tracking locations, and observations of tracks and pellet groups.

[b]Number of observations is insufficient to delineate a range.

Grouping Behaviour

We used a total of 170 observations (n) to estimate mean group size for the different seasons: 44 visual sightings and 126 track observations. Caribou were gregarious during autumn, winter and early spring and essentially solitary during late spring and summer. Mean group sizes (calves included) were: early spring 5.8 (n = 16, range 1 to 19, SD = 5.6); late spring-summer 1.2 (n = 55, range 1 to 3, SD = 0.4); autumn 6.2 (n = 17, range 1 to 24, SD = 5.9); and winter 5.5 (n = 82, range 1 to 17, SD = 3.6). Only the late spring-summer value differed significantly from other seasonal means (Tukey's $P < 0.05$). When calendar dates of seasonal change are used for all seasons, only the summer value differs significantly from other seasonal means (Tukey's $P < 0.05$): spring 3.8 (n = 30, range 1 to 19, SD = 4.6); summer 1.1 (n = 41, range 1 to 2, SD = 0.3); autumn 6.2 and winter 5.5 as above.

Caribou groups dispersed in late April, hence our separation of early spring observations from those of late spring and summer. From May to September, Caribou were usually observed as singles or pairs. Caribou aggregated in late September and the largest groups were observed in early December (i.e. late autumn).

Discussion

We recognize three sources of bias in our habitat data, but we believe our method of following Caribou tracks acted to counter this effect. Firstly, our aerial

observations were probably subject to visibility bias that increased the proportion of observations in open habitats; 199 of 434 (46%) observations of habitat use from December to April were recorded during aerial surveys. Secondly, although frequent excursions were made into mainland areas during late spring and summer, our primarily water-borne mode of travel during that season may have increased the proportion of observations recorded for lake habitat. Thirdly, it is not known if our surveillance of islands and lakeshores was a disturbance factor reducing Caribou use of lake habitat during late spring and summer.

Nevertheless, seasonal patterns of habitat use by Aikens Lake Caribou are similar to those reported for other boreal forest herds (Simkin 1965; Fuller and Keith 1981). Habitat use and movements appeared to be governed at least in part by food preferences and availability, and snow cover conditions. Summertime use of islands and lakeshores was less than that reported for Woodland Caribou in central Manitoba (Shoesmith and Storey 1977), but similar to observations at Wells Gray Park, British Columbia (Edwards and Ritcey 1959). Aikens Lake Caribou were recorded more often than expected on frozen lakes during early spring, in semi-open and open bogs during autumn through early spring, and on mature coniferous uplands during later winter through summer (Table 1). Total use of lowland habitats was greater than expected but comparable to use of upland habitats. Fuller and Keith (1981) reported selection of lowland habitats by Caribou in northeastern Alberta during all months except August. The observed responses of Aikens Lake Caribou to changing snowcover in semi-open and open bogs agreed with Stardom's (1975) threshold values for snowcover thickness and maximum hardness, but not for maximum density.

During the study Aikens Lake Caribou occupied essentially the same range year round. Seasonal ranges were largely overlapping and varied in size among years. The winter ranges were located within the 235 km^2 wintering area reported by Stardom (1975) for 35 to 37 Aikens Lake Caribou during 1971 and 1972. This sedentary behaviour differs from movements of other Woodland Caribou. Moisan (1958), Edwards and Ritcey (1959), Bergerud (1973, 1974), Dauphiné et al. (1975), Freddy (1979) and Oosenberg and Theberge (1980) all reported seasonal range shifts. Fuller and Keith (1981) reported considerable variation among individual ranges; some Caribou concentrated their seasonal activity in areas separated by 17 to 48 km, while others had no identifiable seasonal ranges. Shoesmith and Storey (1977) reported seasonal range shifts, although Shoesmith (1978) indicated that movements varied among individuals.

Seasonal mean group sizes of Aikens Lake Caribou varied significantly during late spring and summer only, but were comparable to findings of Shoesmith (1978) for Caribou in central Manitoba, and of Simkin (1965) and Fuller and Keith (1981) for Caribou in Ontario and northeastern Alberta respectively. Segregation of adult bulls in winter did not occur at Aikens Lake as in northeastern Alberta.

No specific calving area was observed at Aikens Lake, nor were post-calving aggregations formed as often occurs in Newfoundland, (Bergerud 1974), the Yukon (Oosenburg and Theberge 1980) and Quebec (Dauphiné et al. 1975).

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Vocalizations of the Boreal Owl, *Aegolius funereus richardsoni*, in North America

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Bondrup-Nielsen, S. 1984. Vocalizations of the Boreal Owl, *Aegolius funereus richardsoni,* in North America. Canadian Field-Naturalist 98(2): 191–197.

Vocalizations of Boreal Owls *Aegolius funereus richardsoni*were recorded in the field and analysed. I identified six adult vocalizaitons: *Staccato Song* (male, courtship song), *Prolonged Staccato Song* (male, from nest, probably to entice female to nest), *Moo-a Call* (contact), *Skiew Call* (scolding/aggressive), *Chuuk Call* (female, in response to subdued *Staccato Song* of male), and *Peeping Call* (female, response to male arriving with food for the female on the nest). Calls apparently unique to young Boreal Owls are: *Chirp Call* (food begging) and *Chatter Call* (distress). The vocalizations of the allopatric Tengmalm's Owl, *A. f. funereus,* appear very similar, although its primary song is slower and has fewer notes than that of the Boreal Owl, and the *Chuuk Call* has not been recorded for the Tengmalm's Owl.

Key words: vocalizations, Boreal Owl, *Aegolius funereus.*

Seton (1912) romantically described the "love song" of the Boreal Owl (*Aegolius funereus richardsoni*) as "the slow tolling of a short but high-pitched bell ting, ting, ting", and the Montagnais Indians likened the voice of this owl to the sound of water-dripping (Comeau 1923). These two misleading descriptions of the primary vocalization of this species (Bent 1938; Karalus and Eckert 1974) are partly to blame for our lack of knowledge of this owl since it is seldom seen or heard. The biology of the conspecific Tengmalm's Owl (*A. f. funereus*) in Europe is well known (Kuhk 1949, 1953; König 1964, 1968; Noberg 1964). My purpose is to describe and analyse Boreal Owl vocalizations, to present the behavioral contexts in which they are uttered and their possible functions, and to make comparisons with vocalizations of Tengmalm's Owl.

Methods

I studied Boreal Owls from 26 March to 19 July 1974, and 19 March to 2 July 1975 near Kapuskasing, Ontario, and from 17 March to 20 May 1976 near Lesser Slave Lake, Alberta. Both study areas were in mature mixed boreal forest (Rowe 1972).

Boreal Owls proved easy to locate by playback or by listening for males singing on territories. Vocalizations were recorded with a Uher 4000 Report-L tape recorder at a tape speed of 19 cm/sec and an Uher M537 microphone mounted on a 45 cm Dan Gibson plastic parabolic reflector in 1974 and 1976. A 72 cm aluminum parabolic reflector was used in 1975. The primary song was taped for 17 different territorial males, and on several occasions during the night and throughout the courtship period of each male. Other vocalizations were taped whenever possible.

For the analysis of the vocalizations, tapes were played on a Studer tape recorder at a tape speed of 19 cm/sec. Sonagrams were made with a Kay Electric 6061B Sona-Graph using a wide band filter. A narrow band filter was used to determine the frequency of the primary song more accurately. Means and standard deviations are presented throughout.

Results

The *Staccato Song* (Figure 1A) is the primary song given by male Boreal Owls during the night throughout late winter and early spring. The song closely resembles the winnowing of the Common Snipe (*Gallinago gallinago*) and the two may easily be confused. The *Staccato Song* is a "trill" of essentially uniform

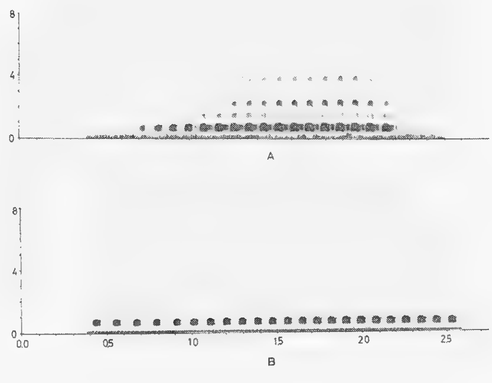

Figure 1. Sonagrams of Boreal Owl songs:
A. — *Staccato Song*
B. — *Prolonged Staccato Song*

pitch. As each song is given it sounds increasingly clear, hollow and penetrating and this quality is reflected in the harmonics, which do not become distinct until the latter ¾ of each song phrase. Individual songs average 1.8 sec in duration (see Table 1) and increase in loudness especially at the beginning.

TABLE 1. Characteristics of the *Staccato Song* of the Boreal Owl.[1]

	Mean	S.E.	Max.	Min.
Ave. freq. (kHz)	0.74	0.003	0.90	0.50
Ave. inter-note length (sec)	0.06	0.001	0.19	0.02
Ave. note length (sec)	0.06	0.001	0.10	0.02
Number of notes	16.09	0.185	23	11
Length of song (sec)	1.80	0.018	2.32	1.32

[1]Based on 160 sonograms from 17 different owls.

On clear cold nights the song was easily audible to the average human ear at 1.5 km, and once I heard a Boreal Owl from a distance of 3.5 km. *Staccato Song* is ventriloquial, and I often had difficulty in determining the exact location of the singing owl in a tree.

Early in the season *Staccato Song* is only given for brief periods in the early evening. As time goes on singing intensity increases and Boreal Owls may be heard singing most of the night. Males unsuccessful at attracting mates slowly diminish singing intensity; however, successful males virtually stop singing shortly after pair formation. *Staccato Song* was uttered only when the owl was perched.

The *Staccato Song* may be uttered in subdued form lacking the clear hollow sound; this lacks the harmonics and is variable in length. The subdued *Staccato Song* is given for 1 to 2 min when the owl starts singing in the evening or after a long pause. It is also uttered by males when approaching the nest with food for the female and young and after being disturbed during the day.

The *Prolonged Staccato Song* (Figure 1B) is given by the male. When a female arrives on his territory, the resident male flies to the nest tree uttering this song, enters the nest hole, and then sits in the entrance giving the song. This song is not divided into phrases but is continuous for up to 1 min. There are no harmonics, and the song lacks clearness and brilliance. Note and internote length are similar to those of the *Staccato Song*; any variability appears to depend on the state of excitement of the male.

On 25 April 1974, a male gave this song for about 15 min, with pauses lasting 1 to 2 sec at approximately 1 min intervals. At peak singing intensity, I was able to evoke *Prolonged Staccato Song* from two owls by giving a short, soft, high-pitched whistle. Unfortunately I was not able to determine what sound the female makes when approaching the male, so I do not know if my whistling imitated the female. This song apparently follows the *Staccato Song* in the reproductive cycle; once *Prolonged Staccato Song* was given, *Staccato Song* was no longer given regularly, if at all.

The *Moo-a Call* (Figure 2A) is variable and may sound like anything from the crying of a child to the creaking of a tree in the wind, but is recognizable on sonograms. The call starts out softly and then increases in both intensity and pitch, ending with an accent and a slight drop in pitch. Once, when I had hung a bow-net trap up at the nest entrance to catch the male when he came, he gave the *Moo-a Call* and flew by the nest. A few minutes later he flew to the nest, avoiding the trap, uttered the subdued *Staccato Song,* and left a prey item in the nest. On all other occasions I noted this call only in response to playback of the *Staccato Song.* Playback of *Moo-a Call* to males actively singing evoked no response.

On 24 June 1974 I evoked the *Moo-a Call* (Figure 2B) by playback of *Staccato Song* on a territory in which I saw fledglings. I do not know if it was an adult or young giving the call.

The first part of a call recorded on 28 March 1974 (Figure 2C) was similar to the *Moo-a Call*, but with a second part with a relatively high frequency note (2.3 to 2.7 kHz) lasting only 0.05 seconds. This call was heard several times in succesion, but only from one bird.

The *Skiew Call* (Figure 2D) is short and loud. A very short preliminary syllable precedes the louder longer syllable by 0.01 to 0.02 sec. The dominant syllable shows a drop in frequency. The minimum and maximum frequencies of the call (fundamental note) averaged 0.53 kHz and 1.37 kHz and the length of the call was 0.08 sec (N = 3).

I was unable to determine if both sexes uttered the call. I heard *Skiew Call* on several occasions in response to playback of *Staccato Song.* On six occasions I heard the *Skiew Call* apparently uttered in response to my presence in the territory of an owl. This call was given by a male when I was near his nest on 9, 13 and 15 May 1975. This owl also gave subdued *Staccato Songs*. Calls reminiscent of the *Skiew Call* (Figure 2E) were recorded on 24 June 1974 in response to the playback of *Staccato Song*. The age of the calling bird could not be determined, but it could have been an immature. The mean minimum and maximum frequencies of the call were 0.82 ± 0.02 kHz and 1.60 ± 0.09 kHz, and the mean length of the call 0.13 ± 0.02 sec (N = 5). In November 1974 I played *Staccato Song* at several locations in the Kapuskasing study area, evoking the *Skiew Call* from two different Boreal Owls.

The *Chuuk Call* (Figure 2F) is a harsh, frequency-

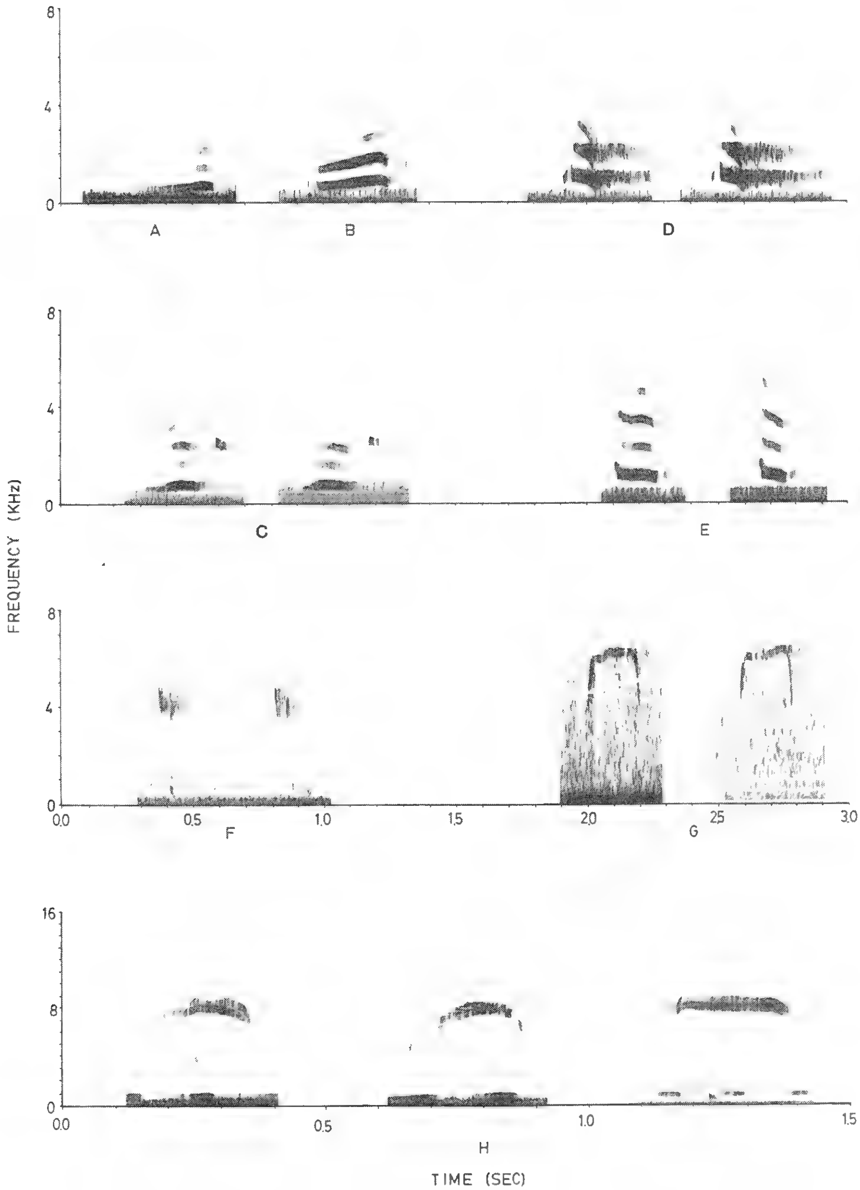

FIGURE 2. Sonagrams of various Boreal Owl vocalizations:

A. — *Moo-a Call.*
B. — *Moo-a Call* of young or adult.
C. — *Moo-a* like call.
D. — *Skiew Call.*
E. — *Skiew*-like call of young or adult.
F. — *Chuuk Call.*
G. — *Peeping Call* of female flying near nest.
H. — *Peeping Call* of female on nest.

modulated call uttered by the female on a male's territory. I recorded it only once; the minimum and maximum frequencies were 3.5 and 5.0 kHz and the duration approximately 0.1 sec. The call was first heard on 9 April 1975, by which time the male only sang once or twice in the evening. The female generally responded immediately with two *Chuuk Calls* from somewhere nearby after the male uttered the first subdued *Staccato Song* of the evening. Likewise in the early morning the male would utter the subdued *Staccato Song* once or twice and the female would answer with the *Chuuk Call*. I heard the *Chuuk Call* following the subdued *Staccato Song* on six evenings and mornings.

The *Peeping Call* (Figures 2G and H) given by the female is pure-toned, starting with a rapid increase in pitch and followed by a sustained segment before terminating with a rapid drop in pitch. One female on a nest regularly uttered the *Peeping Call* in response to subdued *Staccato Song* by the approaching male. By imitating subdued *Staccato Song* I stimulated this female to respond from the next with a rather muted *Peeping Call*, which I was able to record (Figure 2H). The call began at 5 kHz, attained 7.5 to 9.0 kHz for approximately 0.2 sec and then dropped to 5 kHz. It appeared to be composed of two harmonically unrelated sounds from the separate bronchi.

On the night of 3 April 1975 I heard the *Peeping Call* (Figure 2G) given on territory by an owl circling at tree-top level (30 to 40 m). I believed it to be a female because the resident male was giving the subdued *Staccato Song* periodically at the same time. The next day a bird, presumed to be the same female, was found in a hole in the tree marked the previous night at the site of the calling. This *Peeping Call* (Figure 2G) closely resembled that of the female on the nest (Figure 2H), but was of lower frequency, with the sustained part of the call between 5.8 and 6.4 kHz and the start and end of the call about 4.0 kHz. The durations of both calls (Figures 2G and H) were approximately 0.2 sec.

The *Chirp Call* (Figures 3A and B) is given by young Boreal Owls. Before fledging, it (Figure 3A) is very harsh, with a broad frequency spectrum, and is 0.10 to 0.15 sec ($\bar{x}$ = 0.12 ± 0.01 sec, N = 10) in length. The greatest energy of the call is concentrated from 3.3 to 5.0 kHz with an average spread in frequency of 1.34 ± 0.05 kHz (N = 10). The minimum and maximum frequencies of the fundamental averaged 3.53 ± 0.04 kHz and 4.87 ± 0.04 kHz (N = 10). The *Chirp Call* was given by the young when I placed food in the nest. The call seemed to stimulate the female to feed the young, and I heard the call in this context on 6, 8 and 9 June 1975.

After fledging, the *Chirp Call* (Figure 3B) was not as harsh, and sometimes consisted of a pure tone. The energy was concentrated in roughly the same frequency band as in nestling Boreal Owls. The call length averaged 0.16 ± 0.07 sec (N = 13). The *Chirp Call* was given frequently by the fledglings as they flew from tree to tree, ceasing for some time after they had been fed.

The *Chatter Call* (Figure 3C) given by nestlings usually consists of two to four groups of two-note complexes uttered in rapid succession. The notes of the two-note complexes are separated by only 0.01 to 0.02 sec intervals. The minimum and maximum frequencies averaged 1.19 ± 0.09 kHz and 3.37 ± 0.11 kHz (N = 35). Individual note length averaged 0.04 ± 0.003 sec (N = 30) and intracouplet length averaged 0.29 ± 0.02 sec (N = 25).

The *Chatter Call* has one or two harmonics and some notes are frequency modulated. Nestlings gave this call from within the nest and when handled out of the nest. On 18 June 1975 I observed the two youngest nestlings giving the *Chatter Call* as they tried to push themselves under the female to be brooded.

Discussion

The *Staccato Song* is distinctive. It is the only really loud vocalization of the Boreal Owl and is given tirelessly, but only for a brief period in early spring. Kuhk (1953) regarded Tengmalm's Owl as probably the best and most persistant singer among owls, although only for a short period in late winter and early spring. Boreal Owls responded to a recording of the similar song of the Tengmalm's Owl from Sweden with the *Staccato Song* as well as with the *Skiew Call*. The average number of notes from six songs of this Swedish recording was 15.2 ± 0.75; but the number in Germany varies only from 3 to 9 (Kuhk 1953; König 1968). The average number of notes of the Boreal Owl is 16.1 (Table 1). Thus Tengmalm's Owl from Germany has fewer notes in its song than the same subspecies from Sweden or than the Boreal Owl.

The primary song of Tengmalm's Owl in Germany (Kuhk 1953) is similar in length to that of the Boreal Owl, but note length in Tengmalm's Owl is about twice as long. Thus Tengmalm's Owl sings more slowly and possibly resembles Saw-whet Owls (*Aegolius acadicus*) except that the song is discontinuous. The frequency of the song of Tengmalm's Owl is 0.8 kHz (Kuhk 1953), but sonagrams shown by König (1968) have a frequency close to 1 kHz. The average frequency of the *Staccato Song* of the Boreal Owl is 0.740 kHz, with a maximum of 0.90 kHz, so the frequency appears lower in the North American subspecies. The one Tengmalm's Owl song from Sweden had a frequency similar to the Boreal Owl.

Staccato Song appears to be used mainly to attract

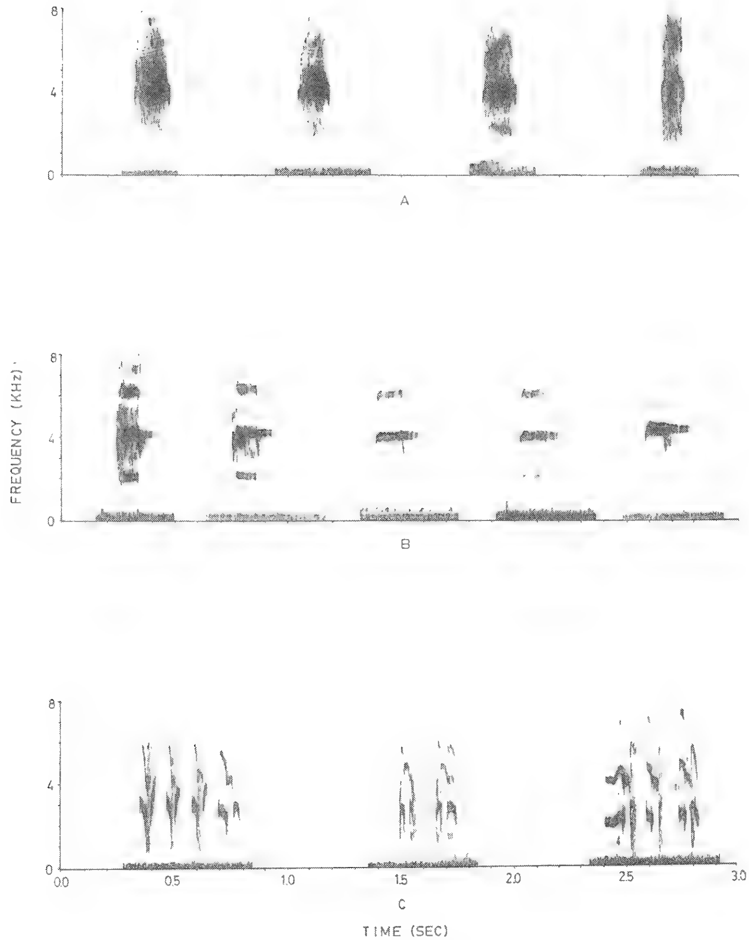

FIGURE 3. Sonagrams of juvenile Boreal Owl vocalizations:
A. — *Chirp Call* of nestlings from nest.
B. — *Chirp Call* of fledglings from a nest near Edmonton, Alberta.
C. — *Chatter Call*.

a female. Only the male Boreal Owl gives *Staccato Song*, as is true for "reviergesang" (primary or territorial song) of Tengmalm's Owl (König 1968; Kuhk 1953). Once a pairbond has been established the *Staccato Song* ceases within a few days, although the subdued *Staccato Song* may be uttered occasionally. In the Whiskered Owl (*Otus trichopsis*) primary song also declines after the pairbond has been established (specifically with the onset of copulatory behaviour; Martin 1974). Continuing intense utterance of *Staccato Song* by a male Boreal Owl indicates that he is unpaired.

The *Prolonged Staccato Song* used by the male to show the female the nest hole is usually only heard when the female first arrives on the territory. The male Elf Owl (*Micrathene whitneyi*) also has a modification of the primary (courtship) song used to show the female the nest (Ligon 1968).

The "triller" and "roller" calls of Tengmalm's Owl (Kuhk 1949, König 1968) are functionally and structurally the same as the *Prolonged Staccato Song* of the Boreal Owl. Kuhk (1949) stimulated the "Triller" call by imitating the "muid" call (=*Moo-a Call* of the Boreal Owl) of the female, but playing the *Moo-a Call* to a Boreal Owl failed to evoke *Prolonged Staccato Song*. A short-high pitched whistle evoked the *Prolonged Staccato Song* from two male owls.

The *Moo-a Call* is highly variable and is apparently only given by males. The similar "stimmfuhlungslaute" (König 1968) or "muid" (Kuhk 1953) was given by both sexes as a contact call and was also given by the male when he arrived at the nest with food.

The *Skiew Call* of the Boreal Owl is probably a scolding call with aggressive/warning connotations. It was uttered most intensely by the male when I was near its nest. On other occasions, including fall and winter, I heard it in response to playback of the *Staccato Song*. The *Skiew Call* is also variable, probably depending on intensity of arousal, through less so than the *Moo-a Call*. It corresponds to the "schreck" of Tengmalm's Owl (König 1968), which is used as a warning call by both sexes when disturbed on the territory. It is the second loudest call in both subspecies and can be heard farther than 100 m. The "schreck" call can become a piercing screem (König 1968).

The *Chuuk Call* of the female Boreal Owl has not been reported for Tengmalm's Owl. One female gave this call on a few nights in response to subdued *Staccato Song* of the male. This pair of owls did not nest as far as I could determine. I am unaware of use in other contexts.

The *Peeping Call* of the female Boreal Owl resembles the "seeh" nest call of the female Tengmalm's Owl (Konig 1968). It is given in response when the male announces his arrival at the nest with food. The ventriloquial properties of this call make location of the source (the nest site) less obvious to predators.

Juvenile Boreal Owls gave only a food-begging call (*Chirp Call*) and a distress call (*Chatter Call*). Clark (1975) also recorded only two basic calls of similar function for juvenile Short-eared Owls (*Asio flammeus*). As a young Boreal Owl matured, the *Chirp Call* changed in quality from harsh to an almost pure-toned call. The food-begging call of young Tengmalm's Owls in the nest is similar to that of young Boreal Owls. When the young fledge, the pitch of the call decreases (König 1968), and this decrease in pitch on fledging also occurs in Short-eared Owls (Clark 1975). I did not find this in Boreal Owls but I followed the development of fledglings for only a few days.

The *Chatter Call* of juvenile Boreal Owls appears to be a distress call. Juvenile Tengmalm's Owls have a similar call with the same function (Koinig 1968). Konig also described a "zit-zit" call given by fledged Tengmalm's Owls but I did not record such a call from fledged Boreal Owls.

Boreal Owls also snap their mandibles and hiss, common defence utterances of owls (Bent 1938).

The vocalizations of the two allopatric subspecies of *Aegolius funereus* are generally similar. The primary song of both subspecies is approximately of equal duration but the Boreal Owl can have up to twice as many notes per song. The Boreal Owl is not an easy bird to study and a larger sample may show subtle differences from the calls of Tengmalm's Owl.

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Establishment of Freshwater Biota in an Inland Stream Following Reduction of Salt Input

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Replacement of halophilic organisms by freshwater ones in and near an inland stream is reported, apparently for the first time. Wolf Creek has received salt waste from a processing plant for almost 100 years. By 1926 the salinity ranged from marine to brackish. *Enteromorpha intestinalis* Agardh and *Ruppia maritima* L. grew abundantly in the stream. On a flat near the salt works were three halophytes: *Salicornia europea* L., *Spartina patens* (Ait.) Muhl. and *Juncus gerardii* Loisel. Insects in the stream were limited to the Salt Fly (*Ephydra subopaca* Loew), Biting Midge (*Culicoides varipennis* (Coquillett)), and two others. In the ten years following reduction of salt input, most of the biota of 1926 have disappeared or greatly retreated. The submerged plants have been replaced by freshwater algae and species of *Potamogeton,* with freshwater emergents now also present. On the flat only *Juncus gerardii* remains of the halophyte species. In the spring of 1979, with the stream generally in the freshwater range of salinity, 17 families, including 21 identifiable genera, of aquatic insects were found. Two additional families were found in the fall of 1981. A study of diatoms in spring showed a freshwater assemblage, but at the highest salinities, near the salt works only, the floral diversity was reduced and the salt-tolerant species *Cocconeis pediculus* Ehr. increased greatly in relative importance. Fish were few in the stream and their numbers and kinds could not be related to salinity. Present salinity ranges from fresh (below 500 mg/1 NaCl) to brackish. The highest value recorded in 1979–81 was 3850 mg/1. Salinity was greatest during the low water season, usually late summer and fall, but pulses of less saline water accompany each rain or thaw. Under these fluctuating conditions, sometimes brackish, the freshwater biota maintains itself successfully for part or all of the year. It is a reasonable conclusion that the changes observed in biota do represent a recovery of the stream ecosystem to its condition before waste salt changed its character. Unfortunately, a unique, inland salt-tolerant biota has been lost as a consequence of controlling the entry of the salt.

Key Words: aquatic macrophytes, benthic invertebrates, diatoms, freshwater biota, halophile, saline stream, salinity, stream recovery.

The introduction of large quantities of salt (NaCl) into freshwater environments is known to disturb the resident biota. Beadle (1957) has noted that the aquatic insects, for example, are generally intolerant of saline waters. Biglane and Lafleur (1954) reported that oil field brines quickly eliminate insects and some crustaceans from streams although fishes, in contrast, are less disturbed.

According to Waisel (1972), vascular plants are generally intolerant of salt, however, some thrive under saline conditions. Such halophytes are common to coastal regions and occur inland where salinity is too high for intolerant forms to survive. A general treatment was provided by Ungar (1974), and the halophytic plants of southern Ontario were reported with ecological considerations by Catling and McKay (1980). The same investigators also reviewed the occurrence of halophytes in the eastern Great Lakes Region (Catling and McKay 1981). Their review included the vascular halophytes of Wolf Creek, subject of this report.

Highway de-icing operations have been a principal source of salt contamination in parts of the Northern United States (Judd 1970; Bubeck et al. 1971; Hutchinson 1971; and Kunkle 1971). Contamination with salt in the vicinity of mining operations has also occurred but has received less attention (Harper 1976).

In general, streams tend to recover from disturbance fairly rapidly. Stream currents reduce the effects of contamination to local phenomena and, given sufficient velocity and volume, a single release of contaminant causes only short-term damage. This is the pattern known well from many studies of point source pollution, particularly those measuring organic matter or dissolved oxygen level. Mineral discharges follow much the same pattern. Long-term changes in stream water quality and in biota usually result from frequent or continuous additions of contaminants (Krumholz and Neff 1970).

Data on inland saline streams are scarce. Jewell (1927) and Retallack and Clifford (1980) studied fauna of intermittent prairie saline streams. Both found the fauna to resemble that of ponds more closely than that of streams. Retallack and Clifford (1980), collecting in Sounding Creek, Alberta, found *Eubranchipus bundyi*

Forbes and *E. intricatus* Hartland-Rowe (Fairy Shrimp: Crustacea, Anostraca), *Lynceus brachyurus* (Harger) and *L. mucronatus* (Packard) (Clam Shrimp; Crustacea, Chonchostraca). All of the species are typical of ponds or temporary pools. *Daphnia* spp. and its relatives were also reported. These Crustacea are generally more typical of lakes and ponds than running waters. However, the stream was in effect reduced to ponds and pools in late summer. This offers little basis for comparison with Wolf Creek which flows continually and has been receiving a constant but fluctuating saline input.

Wolf Creek is a salinized tributary of the Genesee River in Wyoming County of Western New York. Historical records on Wolf Creek are meager. No proof exists that Wolf Creek was previously a freshwater stream, however, the size and distribution of present salt sources indicate that natural saline input could not have raised salinity above 500 mg NaCl. A biotic and chemical shift from fresh to estuarine water presumably occurred before 1890. A salt extracting and processing works began operating adjacent to the stream in 1884 and discharged brine effluent into it. Some observations on salinity, benthic invertebrates, and flora were published over fifty years ago (Claassen 1927; Muenscher 1927). Now a documented reduction in stream salinity has been achieved by control of brine discharged by the salt works and a biotic succession within and along the creek is demonstrable. The changes evoke a paradox in value judgment. On one hand, pollution has been controlled and freshwater biota reestablished. However, a unique and rare inland salt-tolerant biota has been largely destroyed.

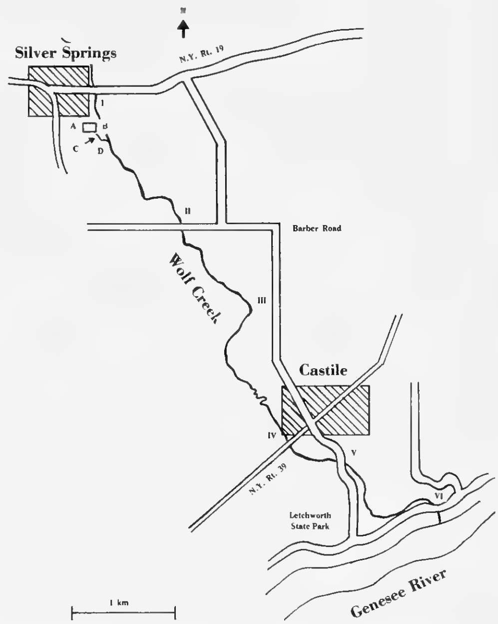

FIGURE 1. Map of Wolf Creek showing sampling sites (I–VI) plus salt works (A), area of cooling ponds (B), drainage ditch (C), flat (D), and business districts of Silver Springs and Castile, N.Y. Data for Sites IV and V were similar and the stations are usually treated as a single site.

Description of Study Sites

Wolf Creek (Figure 1) originates in a swampy area near the hamlet of Silver Springs, New York, and flows in a southeasterly direction for 10 km where it enters the Genesee River. Near its source the stream is sluggish. Riffles are few and poorly defined. The substrate is generally fine sediment, although small, diatom-encrusted rocks are present. The salt works is located less than one km from the source. Until the early 1970's, brine effluents were discharged directly into the stream. The processing has since been altered to recycle wastes. However, thermal effluents with some dissolved salt are discharged into a circle of cooling ponds formed by impounding the creek. Overflow from the ponds enters the stream. Some outflow from the works enters a 50 m ditch which empties into Wolf Creek. The ditch also drains a flat area used for disposal of solid wastes of the extracting processes. The flat is approximately one ha in size and lies between the salt works and the stream immediately downstream from the cooling ponds. Silver Springs is not sewered, but there is no visible domestic sewage in this part of the stream.

Downstream of the flat and salt works, current velocity increases continually to the mouth of the stream. The substrate immediately downstream of the flat is composed of medium-sized stones (5–10 cm in diameter), which are replaced downstream by large (20 cm or greater), ones. The stream flows through the Village of Castile, New York, where septic effluents enter it. Forest et al. (1979) recorded fecal coliform counts of 33 000/100 ml water above the village. These were reduced to a maximum of 3 000/100 ml water at the lower boundary.

Wolf Creek empties into the Genesee River within Letchworth State Park. It tumbles over some small waterfalls and eventually cascades over a series of precipitous drops as it enters the Genesee. The scrubbed substrate here is largely massive bedrock. The entire length of the stream is less than 10 km.

Given the unique history of Wolf Creek for an

inland stream, six sampling areas were selected to obtain observations on the present impact of the salt works at Silver Springs on Wolf Creek (Figure 1). Site I was located at a road crossing in Silver Springs approximately 0.75 km upstream of the salt works. At this site the current velocity is minimal and the substrate is composed mostly of fine detritus. Site II, also at a road crossing, located approximately 1.5 km downstream from the salt works, had a noticeable flow and a substrate composed of small (1–3 cm in diameter) to medium (5–10 cm) sized stones. Sites III–V were within the Village of Castile: III near the northern limits, approximately 2.0 km downstream from Site II (3.5 km below salt works); IV approximately 2.0 km downstream from III (5.5 km from works); and V less than 1.0 km downstream from IV (6.5 km from works). Current velocity at all three were intermediate; substrate composition was medium-sized stones at II and medium to large (20 cm or greater) stones at IV and V. Site VI was within Letchworth State Park, approximately 2.5 km downstream from Site V (9.0 km from works) and 100 m from the mouth. Current at this site has increased over the upstream velocity, and the substrate is largely massive, scrubbed bedrock. Since the data collected at Sites IV and V were found to be virtually identical, the two were subsequently treated as single.

Methods

Salinity is the unique abiotic factor of Wolf Creek, and the only one on which any historical information is available. Consequently, chemical analysis of the water was restricted to this parameter. Estimates for sodium ion concentration were made by flame photometry according to the procedure of Pietrzyk and Frank (1974) and NaCl concentration calculated. Five determinations of sodium ion concentrations were made on each water sample and total salinities were calculated from sample means. Water samples were collected in 1 liter plastic bottles on five dates in 1979; 5 March; 9 and 25 April, and 14 and 30 May. Sites I–III were visited on all five dates: Site VI on all but 5 March, when it was inaccessible. Sites IV or V, or both, were sampled on all dates.

The Morton Salt Company provided data on stream flow and salt levels of Wolf Creek water at approximate weekly frequency for Site II from January 1979 through July 1981, and single samplings for August and September 1981 (Figure 2).

A follow-up visit was made to Wolf Creek on 20 September 1981, because the late August and September weather had been unusually wet. The vicinity of the salt works and the stream to Site II were observed carefully for plants; and the invertebrates were collected at Site II.

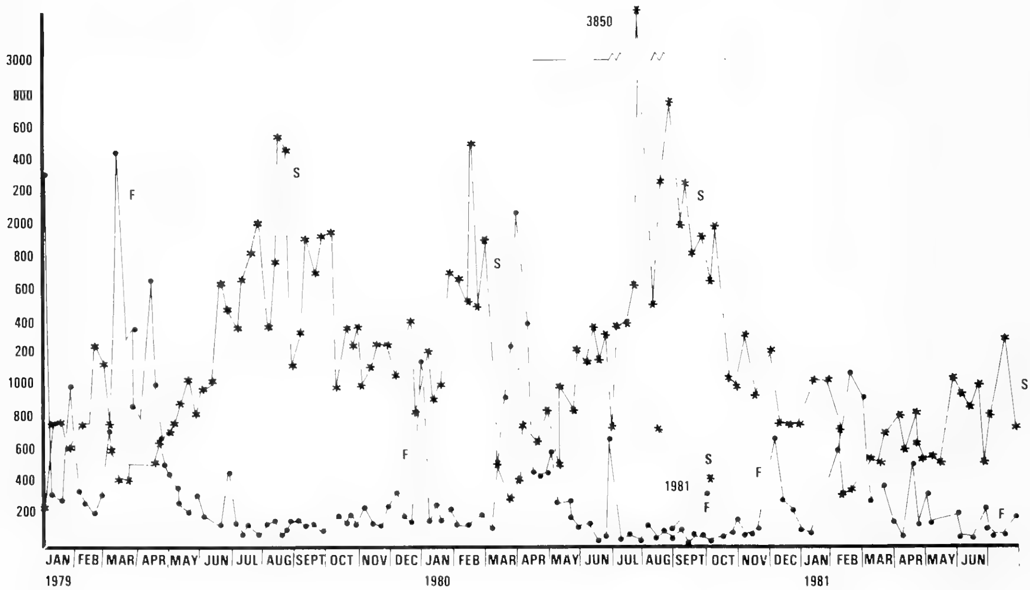

FIGURE 2. Stream flow and salinity in Wolf Creek at Barber Road (Site II) January 1979 through September 1981. Data from velocity and cross section of water, sodium chloride salinity as chloride ion concentrations. (asterisks for NaCl; dots for waterflow)

Sample rocks and submerged plants, particularly filamentous algae, were collected (when present) for epibenthic and epiphytic diatoms respectively. Specimens were dried and cleaned according to the method of Stockner and Benson (1967) and put on slides for identification. Slides were prepared according to a modified version of the Battarbee (1973) procedure and relative proportions of species present were then tallied for transects until 400 frustules had been observed. All collections were made at the times of water sampling.

Other algae and aquatic vascular plant specimens were collected by hand periodically over the spring and summer of 1979. Terrestrial vascular plants growing on the flat and adjacent to the stream were surveyed and collected in 1969 and in 1979–80, as well as being observed casually in the intermediate years and in 1981. Vascular plant specimens are on temporary deposit at the herbarium at the State University College, Geneseo, New York (GESU). They will be sent for permanent deposit at Cornell University (CU), with available duplicates going to the New York State Herbarium at Albany (NYS). Benthic arthropods were collected at the times of water sampling and in September 1981 in moving water with a Ward's wiremesh scraper net and with a Surber sampler. Fish were collected with a standard five-foot (1.55 m) minnow seine. In addition, much of the stream length was observed while wading or walking the stream with attention given to the general stream character and all visible biota.

Results

Salinity

Calculated NaCl concentrations in Wolf Creek between 5 March and 30 May 1979 are given in Figure 3. Maximum concentration occurred at Site II; concentrations increased as the study progressed, corresponding to reduced flow. (Stream flow data were: 2048 l/s on 7 March, 1663 l/s on 11 April, 235 l/s on 17 May 1979). Salinity markedly decreased toward the mouth of the stream.

Generally, during 1979–1981, salinity at Site II fluctuated inversely with stream flow (Figure 2). The seasonal fluctuations were reflections of general precipi-

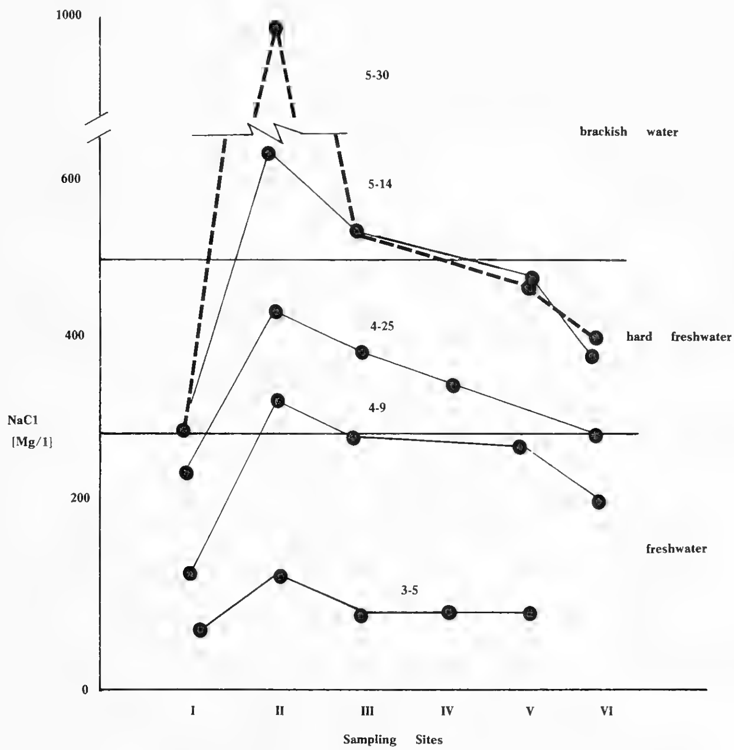

FIGURE 3. Sodium chloride salinities, calculated from sodium ion concentrations, of Wolf Creek water at sampling sites on indicated dates in 1979.

tation, with short sharp changes caused by single rains or thaws. Lowest flows-highest salt concentrations were found from July through October, with the opposite relationship occurring approximately from February into May. Peak salinities reached levels of over 2000 mg/l during most of the drier season, but the concentration dropped frequently below 1500 mg/l and occasionally below 1000. The highest level recorded was 3850 mg/l at the end of July 1980. In the spring of 1979, when samples were taken of fish, benthic arthropods and diatoms, the salinity was at its seasonal minimum.

Diatoms

Although there was no previous record of diatoms from Wolf Creek, a study was undertaken of the present flora owing to their particular value as organisms indicating salinity. Sixty-one diatoms were identified (Table 1). Growth was generally dense; the substrate of most of the stream was completely covered with

TABLE 1. Epibenthic and Epiphytic Diatoms of Wolf Creek. Dominant forms are denoted by *.

Diatom Species	Sampling Sites I	II	III	IV/V	VI
**Achnanthes lanceolata* (Breb.) Grun.	+	+	+	+	+
**A. minutissima* Kutz.	+	+	+	+	+
Amphora sp.	+				
A. ovalis (Kutz.) Kutz.			+		
Asterionella formosa Hass.				+	+
Caloneis amphisbaena (Bory) Cl.	+		+		
C. ventricosa (Ehr.) Meist.		+			
**Cocconeis pediculus* Ehr.		+	+	+	+
C. placentula Ehr.	+	+	+	+	+
Cyclotella comensis Grun.					+
C. meneghiniana Kutz.	+	+	+	+	+
Cymbella cuspidata Kutz.	+		+		
C. microcephala Grun.		+	+	+	
C. minuta Hilse *ex* Rabh.		+	+	+	+
C. naviculiformis Auersw. *ex.* Heib.			+		
C. sinuata Greg.	+	+			
Diatoma tenue Ag.	+	+	+	+	+
**D. vulgare* Bory.		+	+	+	+
Fragilaria capucina Desm.	+			+	
F. construens (Ehr.) Grun.		+			
F. leptostauron (Ehr.) Hust.	+	+	+	+	
F. vaucheriae (Kutz.) Peters	+	+			+
F. virescens Ralfs.		+	+	+	+
**Gomphonema angustatum* (Kutz.) Rabh.	+	+	+	+	+
G. gracile Ehr. emend. V.H.			+		
G. olivaceum (Lyngb.) Kutz.		+	+	+	+
G. parvulum Kutz.		+	+	+	+
G. tergestinium (Grun.) Fricke	+				
Gyrosigma sp.			+		
Melosira varians Ag.		+	+		
**Meridion circulare* (Grev.) Ag.	+	+	+	+	+
Navicula capitata Ehr.		+			+
N. cuspidata (Kutz.) Kutz.	+			+	
**N. cryptocephala* Kutz.	+	+	+	+	+
N. integra (W. Sm.) Ralfs			+		
N. laevissima Kutz.			+		
**N. lanceolata* (Ag.) Kutz.	+	+	+	+	+

(continued)

TABLE 1. Concluded

Diatom Species	Sampling Sites I	II	III	IV/V	VI
N. pupula Kutz.	+	+	+		
N. radiosa Kutz.	+	+	+		
N. rhyncocephala Kutz.	+	+	+	+	+
N. tripunctata (O.F. Mull.) Bory	+			+	
N. virdula (Kutz.) emend. V.H.	+				
Neidium productum (W. Sm.) Cl.	+				
**Nitzschia amphibia* Grun.		+	+	+	
**N. dissipata* (Kutz.) Grun.		+		+	+
**N. fonticola* Grun.		+	+	+	+
N. hungarica Grun.		+			
**N. palea* (Kutz.) W. Smith	+	+	+	+	+
N. sigmoidea (Ehr.) W. Smith	+	+	+	+	
Pinnularia major (Kutz.) Rabh.	+				
P. subcapitata Greg.	+				
**Rhoicosphenia curvata* (Kutz.) Grun. *ex.* Rabh.	+	+	+	+	+
Stauronies phoenicenteron (Nitz.) Ehr.	+				
Surirella angustata Kutz.	+				
S. ovata Kutz.	+	+	+	+	+
Synedra fasciculata (Ag.) Kutz.			+		
S. pulchella Ralfs. *ex.* Kutz.	+	+	+	+	+
S. radians Kutz.	+				
S. socia Wallace			+		

diatom incrustations. In general, the dominant forms were typical of flowing water with medium to high hardness and are typically found in fresh or brackish water (Gasse, 1974; Patrick and Reimer, 1966, 1975).

Diatom diversity at Site II dropped dramatically between 25 April and 15 May 1979. At this site, the stream's typical freshwater diatom flora was replaced by a low diversity, salt-tolerant flora dominated by *Cocconeis pediculus* (Figure 3), corresponding to the rise in salinity above the 500 mg/1 level. At other times and sites during the scope of this study, the diatom flora was characteristically freshwater (Figures 4 and 5).

Other Algae

Algae, other than diatoms, found in Wolf Creek during 1979 were: various blue-green at Site I; *Cladophora glomerata* (L.) Kuetz. at Sites II, III, V, and VI; *Microspora* sp. at Site II; and three species of *Spirogyra* at Site IV. *Enteromorpha intestinalis* Agardh was present in 1969 and the early 1970's at Sites III–VI. It disappeared from the main stream before 1978, but continued to grow in the ditch draining the flat near the salt works. It was not found in September 1981, after a prolonged rainy and cool period. The alga was found in a small pool near the plant in the fall of 1983.

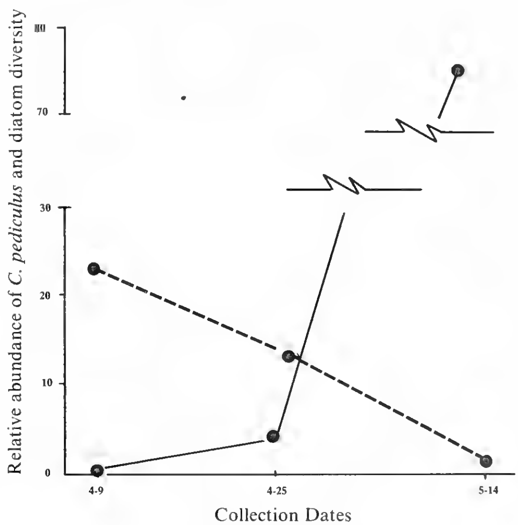

FIGURE 4. Relative abundance of *Cocconeis pediculus* Ehr. as percent of frustules counted (solid line) and diversity as number of diatom taxa accounting for 95% of total frustules counted (broken line) at Site II on indicated dates in 1979.

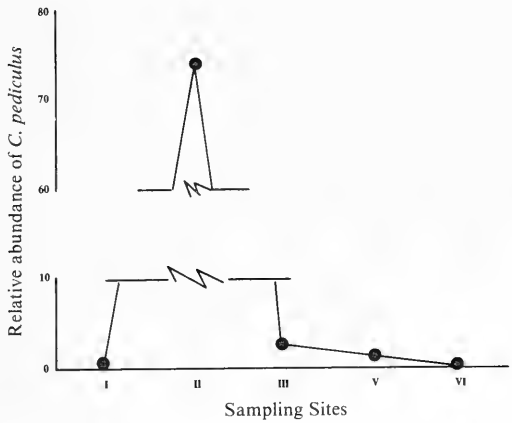

FIGURE 5. Relative abundance of *Cocconeis pediculus* Ehr. as percent of total diatom frustules counted on 14 May 1979, at indicated sampling sites. Data for Sites IV and V were combined.

Vascular Plants

Submerged vascular plants growing in the stream in 1979 were: *Potamogeton crispus* L. (Crimped Pondweed) at Site I; *P. pectinatus* L. (Sago Pondweed) at Site II; and *Elodea canadensis* Michx. (Canadian Waterweed) at Sites III and IV. *P. zosteriformis* Fern. (Flat-Stem Pondweed) has also been collected in the stream between Sites II and III. The cooling ponds of the salt works (which supply overflow to Wolf Creek) supported a flora of freshwater species which are somewhat salt tolerant: *Chara* sp. (Stoneworts), *E. canadensis, Myriophyllum spicatum* L. ("Eurasian" Water Milfoil) and *P. pectinatus.* Indeed, only the flora of the small drainage ditch from the works was noticeably saline.

Emergent and marginal vascular plants growing along the shores of the stream in 1979-80 include plants that were typical of non-marine situations. A good stand of *Carex stricta* Lam. (Erect Sedge) grew beside the stream at Site II and two emergents, *Scirpis americanus* Pers. (Three-Square) and *Eleocharis obtusa* (Willd.) Shultes (Blunt Spike Rush) grew farther downstream near Site III. Manna-grass, *Glyceria* (probably *G. grandis* S. Wats.), was found to grow completely submerged at times.

In 1979, the flat showed almost the same terrestrial flora as observed in 1926 by Muenscher (1927), other than that *Spartina patens* (Ait.) Muhl. (Salt-Meadow Grass) had disappeared. *Salicornia europaea* L. (Saltwort or Chicken Claws) and *Juncus gerardii* Loisel (Black Grass) were present, and *Juncus* continued to grow in 1980, but was invaded by *Phragmites australis* (Cavan.) Trin.* (Reed), and a variety of typical water margin "weedy" plants. *Salicornia,* restricted to a single patch along the edge of a pond in 1979, had disappeared by 1980.

Benthic Arthropods and Fish

A total of 17 families of aquatic insects (21 genera or species were identified) and three families of Crustacea were found in Wolf Creek in 1979 (Table 2). Two families of insects were added in September 1981. The benthic community was not rich, but those organisms captured were typical of fresh water. Site I, which lies upstream of the areas affected by salt, showed the greatest diversity. The salt tolerant forms found by Claassen (1927) were not present.

Few fish were found in Wolf Creek. Specimens of Bluegill (*Lepomis machrochirus* Raffinesque), Blacknose Dace (*Rhinichthys atratulus* (Hermann)), and Golden Shiner (*Notemigonus crysoleucus* (Mitchill)) were captured at Site I. Dace and shiners were also captured at Site II. The Creek Chub (*Semotilus atromaculatus* (Mitchill)) was captured between Sites II and III. Fish within the cooling ponds by the salt works included Bullhead (*Ictalurus* sp.) the Bluegill, Large Mouth Bass (*Micropterus salmoides* (Lacepede)), and the Green Sunfish (*Lepomis cyanellus* Raffinesque) which is rare in the area.

Discussion

The only previous investigations of Wolf Creek were conducted in the middle 1920's. Claassen (1927) found a salinity of 39 000 mg/l immediately below the salt works and of 11 400 mg/l near the mouth, 9 km distant. The higher value is comparable to ocean salinity, while the lower is within estuarine limits (Reid and Wood, 1976). Claassen (1927) reported that typical freshwater benthic invertebrates were absent from the stream; a species-poor, salt-tolerant community was present instead. He listed larvae of the Salt Fly (*Ephydra subopaca* Loew) as the dominant animal, followed by larvae of the Biting Midge (*Culicoides varipennis* (Coquillett)). Neither was found in 1979. He also listed mosquito larvae and rattail maggots as present, but did not identify them.

Muenscher (1927) reported finding plants in Wolf Creek which are characteristic of coastal or brackish water. The green, saccate alga *Enteromorpha intestinalis* Agardh, a species characteristic of brackish water, was dominant in the stream from the salt works to the mouth. The other algae listed by Muenscher were *Actinastrum hantzschii* Lagerh. (green algae; Scenedesmaceae) and *Spirulina subsalsa* Oersted (blue-green algae; Oscillatoriaceae). Both species are widespread in non-marine habitats, but the second

*Frequently reported as *Phragmites communis* Trin.

TABLE 2. Benthic aquatic arthropods of Wolf Creek, New York.

	Sampling Sites (Key: + =Spring 1979, o = 20 September 1981)				
Taxon	I	II	III	IV/V	VI
Crustacea					
Isopoda					
Lirceus sp.	+	+			
Asellus sp.	+	+o	+	+	
Amphipoda					
Gammarus sp.	+	+o	+	+	+
Decapoda					
Orconectes sp.	+				
Insecta					
Ephemeroptera					
Baetis sp.	+				+
Neocloeon sp.				+	
Stenonema sp.			+		
Plecoptera					
Isoperla sp.	+				
Neoperla sp.	+				
Megaloptera					
Chauliodes sp.		+			+
Corydalus cornutus L.		o			
Sialis sp.	+			+	+
Odonata					
Agrionidae		o			
Trichoptera					
Cheumatopsyche sp.	+	+	+	+	+
Hydropsyche sp.		+o	+	+	+
Limnephilus sp.			+		
Mystacides sp.	+	+			
Neophylax sp.				+	
Oecetis sp.	+			+	
Chimarra sp.		o			
Pycnopsyche sp.			+		
Psilotreta sp.		+			
Hemiptera					
Corixidae	+				
Coleoptera					
Psephenus herecki De Kay		+o	+	+	+
Stenelmis sp.	+	+	+	+	+
Diptera					
Anthomiidae	+	+	+		
Chironomidae	+	+o	+	+	+
Simuliidae	+	+		+	+
Tipulidae					
Antocha sp.		+	+	+	+
Tipula sp.	+				+

species is associated with highly polluted or organic waters. They were not found in 1979 or 1980. Muenscher also found *Ruppia maritima* L., (Ditch Grass) a submersed vascular obligative halophyte (Waisel, 1972), in the stream between the salt works and Castile, but it is no longer present. A specimen of this species was also collected by Muenscher in 1945 from Wolf Creek and is at the Wiegand Herbarium at Cornell University (CU). Another, collected in 1968, is at the New York State Herbarium in Albany (NYS). The latter, the last to be collected, was taken from the drainage in the salt works area, not from the stream proper.

In examining the terrestrial flora growing adjacent

to the creek at the salt works, Muenscher found two species which, according to Waisel, are indicative of saline soil conditions: *Juncus gerardii* and *Salicornia europaea. Spartina patens,* a more facultative halophyte, was also present. Now, only *Juncus* remains.

In contrast to the salinity levels of Wolf Creek reported by Claassen (1927), those presented in this report represent a dramatic reduction. Present levels continue to be highest immediately downstream of the salt works and decrease toward the mouth, indicating that dilution is occurring by tributaries, runoff from land, and perhaps by additions from the Village of Castile as well. The inverse relationship found between salinity and total flow is to be expected (Edwards and Thornes 1973). Salinity in excess of 500 mg/l, the arbitrary lower limit of brackish water (Perkins, 1974; Reid and Wood 1976) did occur during May at Sites II and III. Undoubtedly the water is also brackish at Sites IV and V through much of the summer and fall seasons, although the salinity drops considerably for short periods. Since the brief flushes of water are due to individual rains or thaws, they may be more frequent than indicated by Figure 2. At least during the spring, almost all of the stream is fresh. In this fluctuating environment the biota is characteristic of fresh water.

The salinity of freshwater streams in more or less natural watersheds varies somewhat. Verry (1975), for example, reported an NaCl salinity of 7.6 mg/l in a Minnesota stream draining an upland, peatland watershed and Martin (1979) an annual range of 0.8–4.3 mg/l from a stream in an undisturbed watershed in New Hampshire. Wolf Creek, in contrast, carries a much higher NaCl load, but the change in brine disposal methods by the salt works has lowered stream salinity.

A striking effect of salinity now is discernible for the stream diatom flora. The diatom community at Site II, in particular, continues to be sometimes limited by salt, with *Cocconeis pediculus* dominating the community as salinity increases. Cholnoky (1968) considered *C. pediculus* a halophilic form, as did Hustedt (1957) and Molder and Tynni (1972). Cholnoky listed 500 mg/l NaCl as the minimum salinity at which this species becomes abundant. This level agrees with the results reported here. In contrast, Patrick and Reimer (1966, 1975) considered *C. pediculus* salt-indifferent. Nevertheless, the "brackish water" flora of Site II does not persist at the downstream Sites III–VI (Figure 4) and the abundance of *C. pediculus* is greatly reduced, apparently in response to low salinity levels. The general effect of salt input on the diatom flora, then, appears to be significant, but localized.

The other algae recently present in Wolf Creek are likewise indicative of freshwater with the exception of *Enteromorpha intestinalis,* which survived until recently but only in the drainage ditch near the salt works. Salinity of the ditch water varies with the water and brine runoff, so it is possible that the alga may survive the period of low salt level and reappear when the water is brackish for an extended time. This species is considered to be characteristic of brackish water, although it is sometimes found growing in fresh water near the sea (Whitford and Schumacher 1973). Moreover, the authors have observed it in inland situations in Wyoming and in Poland and Scotland, and it has been reported from saline sites in Ontario (Catling and McKay 1981). Its retreat from Wolf Creek is interpretable as a response to reduced salinity. It is noteworthy that this ditch was the last site for *Ruppia maritina* too. The failure of this vascular plant to survive is evidently due to periodic drying of the ditch and absence of a dependable supply of saline water.

The presently-occurring submerged vascular plants in Wolf Creek are also indicative of fresh water. *Potamogeton pectinatus* is known to be tolerant of some salinity (Hynes 1966). This need not account for its presence at Site II, since it is common in fresh waters throughout the region. Halophilic terrestrial plants are disappearing from the area they previously occupied, and *Juncus gerardii* was the only species mentioned by Muenscher (1927) to be present in 1980. It is clear that a floral succession either is occurring or has occurred both in the stream and on the flat.

Observations of the fauna of Wolf Creek offer less striking evidence of the present effects of salt on the stream. The differences in invertebrate taxa collected at the various sites (Table 2) may reflect abiotic conditions, other than salt (Clemens and Jones 1954), which were not considered. Sites III–V have been found to show evidence of domestic sewage (Forest et al. 1979), and Site VI has a largely inhospitable substrate. Some forms, particularly the Hydropsychidae (Trichoptera), Chironomidae and Simuliidae (Diptera) were abundant on at least one occasion. However, differences in numbers of taxa and individuals collected at each site are not considered meaningful under the limits of this investigation and are not reported.

The collection of insects at Site II in late September, 1981 not only added two new families, but individuals which were found in advanced stages of development. Specimens of *Corydalus cornutus* were over 4 cm long, and *Hydropsyche* sp. were up to 1.2 cm. The former is a particularly long-lived species (Chandler 1968). The size is clear evidence that both must have survived the unusually wet late summer when the salinity was much lower than in previous years, but in the brackish water range at least part of the time. (Figure 2 and Table 2).

In general, aquatic insects are not tolerant of saline waters (Beadle 1957), however, it is of interest to note that some forms which are particularly salt intolerant, especially Ephemeroptera, (Berner and Sloan 1954), were captured at the downstream sites. In comparison, the arthropod community of Wolf Creek was found to be more diverse than that of another Wyoming County stream, the upper Tonawanda Creek, which has little direct human influence upon it and is free of salt (Marcus and Little 1974). In comparison to reported benthic communities in high quality streams (e.g. Mackay and Kalff 1969; Krumholz 1972; Allan 1975; Ward 1975) aquatic arthropods were indeed poorly represented in Wolf Creek. Nevertheless, it is significant that the salt tolerant forms found by Claassen (1927) have been replaced for at least part of the year by more typically freshwater organisms.

Fish offer even less meaningful information. The scarcity of these organisms in the stream has been noted previously in field reports by State fish biologists (Forest et al. 1979). Absence from Site VI is explainable in terms of inadequate cover, but this is not the case elsewhere. Absence cannot be related to salt content since Site II and III, where fish were found, were consistently more saline than the downstream sites which failed to yield fish. Furthermore, according to Biglane and LaFleur (1954) and Beadle (1957) several freshwater fish are tolerant of salinity. Perkins (1974) listed several freshwater species that have been encountered in some more saline areas of river estuaries. It is likely that factors other than salt content are responsible for the scarcity of fish in Wolf Creek.

Summary and Conclusions

Fifty years ago, the water of Wolf Creek contained sodium chloride at levels from marine to brackish. Now, it is brackish only periodically and locally because brine input from a salt works has been reduced from 1972 to the present. Before reduction, a coastal or halophilic biotic community was present in the stream and on flats near the works. Characteristic halophilic algae, vascular plants, and arthropods were present in 1926; at least the plants persisted for some time afterwards. Now, the halophytes are markedly reduced or have disappeared, and non-halophytes grow in the stream and on the flats near the salt works. The fish population is sparse and cannot be related to past or present salt levels. Benthic invertebrates encountered during the study are typical of freshwater streams.

No previous data existed for diatoms, but the current studies show a rise in number of the salt tolerant species *Cocconeis pediculus* and decrease in diversity of other species only near the salt works.

The changes indicate that a succession either has occurred or is occurring. Although the meagerness of historical information prevents the desirable confirmation, the authors are of the opinion that this is a case of stream recovery. It is presumed that the halophytes established themselves as opportunists taking advantage of vacant niches created as salt intolerant forms were eliminated when brine discharge began almost a century ago. The present diatom community suggests this behavior. Reduction of the salt load during the past ten years is presumed to have enabled native freshwater organisms to repopulate the stream while exotics retreated or were exterminated.

In perspective, the most significant finding is the existence of a predominantly freshwater community, even under periodic brackish conditions. The fluctuating conditions are not extreme enough to maintain estuarine species or to prohibit freshwater ones from establishing and persisting. As a whole, the finding testifies to the ability of some freshwater organisms to tolerate salinity above the level which arbitrarily distinguishes freshwater from brackish water for certain periods of time.

Acknowledgments

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Notes on Canadian Sedges, Cyperaceae

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Reznicek, A. A., and P. M. Catling. 1984. Notes on Canadian sedges, Cyperaceae. Canadian Field-Naturalist 98(2): 209–214.

The sedges *Carex seorsa* and *Fuirena pumila*, found in the Niagara Peninsula, Ontario, are additions to the Canadian flora. Reports of *Carex suberecta* in Canada are confirmed, based on old specimens and recent collections in Essex County, Ontario. *Carex emmonsii* and *C. atlantica* subsp. *capillacea* are additions to the Ontario flora. All five taxa have eastern, southern or midwestern distributions in the United States and are believed to have been previously overlooked at their northern limits in Canada. The European *C. sylvatica*, known previously in North America only from Long Island, New York, is reported from four localities in southern Ontario.

Key Words: Cyperaceae, sedges, *Carex*, *Fuirena*, floristics, new records, phytogeography, Ontario, Canada.

Recent field studies as well as examination of herbarium specimens has resulted in both new records and confirmation of previously questionable records. The species involved are all rare native species except for the European *Carex sylvatica* Hudson.

Carex atlantica L. H. Bailey subsp. *capillacea* (L. H. Bailey) Reznicek

This essentially Atlantic coastal plain taxon was previously known in Canada from southern Nova Scotia and two outlying locations in southeastern Quebec (Reznicek & Ball 1980). Its occurrence in Alfred Bog, the first recorded for Ontario, contributes to an interesting phytogeographical pattern. Rhodora (*Rhododendron canadense* (L.) B.S.P.) and Massachusetts Fern (*Thelypteris simulata* (Davenp.) Nieuwl.) are other eastern North American species with stations in Alfred Bog (where they are at their northwestern limits). Several other largely eastern vascular plants have a similar pattern, some occurring at their northeastern or northern range limits in southeastern Quebec (e.g. False Hellebore, *Veratrum viride* Aiton), and others extending into a relatively small portion of the lower Ottawa and lower St. Lawrence valleys of Ontario and Quebec (e.g. an Umbrella Sedge, *Cyperus dentatus* Torrey).

Carex atlantica subsp. *capillacea* occurs extensively but locally over the northeastern section of Alfred Bog, usually growing in moist peaty substrate. It is often dominant or subdominant (in terms of total ground cover) in openings surrounded by Mountain Holly (*Nemopanthus mucronata* (L.) Trel.), Winterberry (*Ilex verticillata* (L.) Gray), Red Maple (*Acer rubrum* L.), Tamarack (*Larix laricina* (Du Roi) K. Koch) and Gray Birch (*Betula populifolia* Marsh.). Associated species included Sedge (*Carex trisperma* Dewey), Dewberry (*Rubus hispidus* L.), Black Chokeberry (*Aronia melanocarpa* (Michaux) Ell.), Sheep Laurel (*Kalmia angustifolia* L.) and Labrador Tea (*Ledum groenlandicum* Oeder).

Carex atlantica subsp. *capillacea* was discovered in 1982 in similar habitat approx. 44 km to the south of Alfred Bog in Newington Bog, Stormont Co. This species was mapped by Ball et al. (1982), but the Newington Bog discovery was too recent to be included. Both locations are shown on Figure 1.

Specimens examined:

ONTARIO, Prescott County. Alfred, [July or August, 1940], *Fr. Barnabé 685* (MT). Alfred Bog, northeast section about 2 miles south of the hamlet of Caledonia Springs in Caledonia Tp., approximately 45°31′N, 74°48′W, 2 July 1981, *P. M. Catling 3333*, (DAO, MICH, TRTE and duplicates to be distributed).

Stormont County, west side of old railway bed, west side of Newington Bog, *P. M. Catling & V. R. Brownell*, 19 June 1982 (DAO, MICH).

Carex emmonsii Dewey

Primarily eastern in range, this species is local in the Great Lakes Region (Mackenzie 1935). The plant was previously known in Canada from Prince Edward Island, Nova Scotia and New Brunswick (Mackenzie 1935; Boivin 1967 (*sub C. nigromarginata* Schw. var. *minor* (Boott) Gleason). Previous reports from Ontario (Scoggan 1978) were evidently based on misidentification (Ball et al. 1982), so that the recent discovery in Wainfleet Bog, Dist. Munic. Niagara, represents the first authentic Ontario record.

Within the Canadian flora, *Carex emmonsii* is similar to *C. artitecta* Mack. from which it is most easily separated by its scabrous-acuminate staminate scales

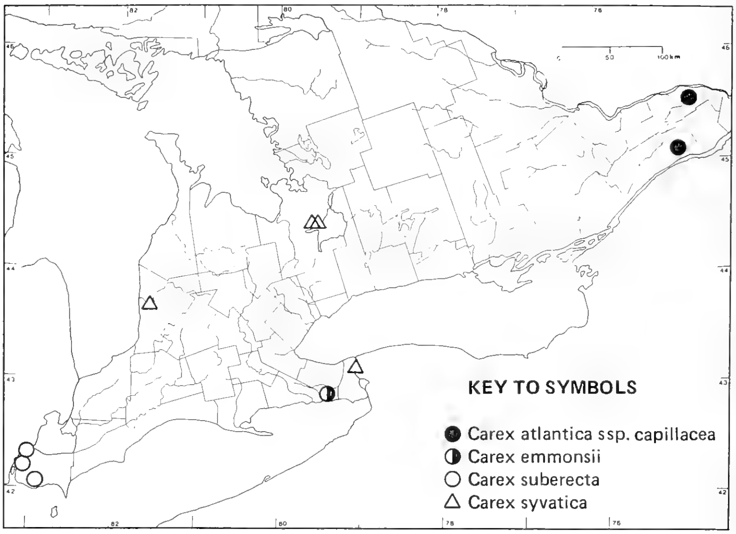

FIGURE 1. Southern Ontario distributions of *Carex atlantica* subsp. *capillacea, Carex emmonsii, Carex suberecta* and *Carex sylvatica.*

with an excurrent midvein. In *C. artitecta,* the staminate scales are obtuse to acuminate, but smooth and more or less flat at the tip without an excurrent midvein (Figure 2). In addition the bract of the lowest pistillate spike frequently exceeds the inflorescence in *C. emmonsii* but rarely does so in *C. artitecta* (Figure 2).

Carex artitecta is a local plant of forests in southwestern Ontario, re-appearing at the head of the St. Lawrence River in St. Lawrence Islands National Park (Ball et al. 1982). In the Wainfleet Bog, *C. emmonsii* occurs locally in the open on dryish, acid peat in more or less disturbed sites within the area of active peat extraction. Associated species included *Aralia hispida* Vent., *Rubus* spp., *Carex scoparia* Willd., *C. cumulata* (Bailey) Mack. and *Linaria canadensis* (L.). Dum. The station is mapped in Figure 1.

Carex emmonsii Dewey, *C. seorsa* Howe and *Fuirena pumila* Torrey, also discussed herein, represent an interesting group of eastern species that occur very locally in the eastern Lake Erie region. Additional species of similar distribution already known from the area include *Carex alata* Torrey (Reznicek and Catling 1982), *Myrica pensylvanica* Loisel. and *Polygonum careyi* Olney, among others. All of these species are plants of open ground, usually occurring most commonly near the Atlantic Coast. Stations inland are often few and scattered.

Specimens examined:

ONTARIO, Regional Municipality of Niagara [Welland County].

Wainfleet Peat Bog, ca. 5 km NW of Port Colborne in Wainfleet Tp., approximately 42°55′N, 79°19′W, 14 June 1981, *A. A. Reznicek & P. M. Catling 3413,* (DAO, MICH, and duplicates to be distributed).

Carex seorsa E. C. Howe

This sedge is largely confined in North America to the Atlantic coastal plain (Reznicek and Ball 1980). Its discovery at four localities in the Niagara Peninsula, Ontario, represents an addition to the flora of Canada. At the stations we discovered, plants were found in partially shaded woodland situations, usually with Red Maple (*Acer rubrum*) and Yellow Birch (*Betula alleghaniensis* Britton) in acid peaty substrate, often around the edges of woodland pools. The most frequent associates were sedges (*Carex trisperma* and *C. canescens* L.), Royal Fern (*Osmunda regalis* L.), Cinnamon Fern (*Osmunda cinnamomea* L.), Marsh Fern (*Thelypteris palustris* Schott) and Highbush Blueberry (*Vaccinium corymbosum* L.). At the stations discovered by D. Langendoen and D. Langendoen and P. F. Maycock, *C. seorsa* occurred in wet Buttonbush (*Cephalanthus occidentalis*) thickets in depressions in Pin Oak (*Quercus palustris*) woodland. These discoveries were in time to be included in the Atlas of the Rare Plants of Ontario (Ball et al. 1982).

Specimens examined:

ONTARIO, Regional Municipality of Niagara [Welland County].

West side of hwy 406 south of Holland Rd, 79°14′N, 43°05′W, 19 May 1981, *D. Langendoen*; 3

FIGURE 2. A, *Carex emmonsii* Dewey, infructescence. Ontario, Wainfleet Twp., Dist. Munic. Niag., 14 June 1981, *A. A. Reznicek & P. M. Catling 3413* MICH). B, *Carex artitecta* Mack., infructescence. Ontario, Point Pelee, Essex Co., 30 May 1910, *C. K. Dodge* (MICH).

July 1981, *D. Langendoen* and *P. F. Maycock*; 4 August 1981 *D. Langendoen and P. F. Maycock*; 13 August 1981, *D. Langendoen* (herb. Maycock).

About 3 km northeast of Port Robinson at 43°03.5′N, 79°11′W, Crowland Tp., 11 June 1981, *A. A. Reznicek and P. M. Catling 3532* (DAO, MICH, TRTE and duplicates to be distributed).

About 2.5 km south-southwest of Fenwick at 43°0.5′N, 79°22′W, Pelham Tp., 13 June 1981, *A. A. Reznicek and P. M. Catling 3442* (DAO, MICH).

Willoughby Marsh Conservation area (formerly Black Creek Swamp) approximately 9 km east of Welland, approximately 42°59′N, 79°06′W, Willoughby Tp., 15 June 1981, *A. A. Reznicek and P. M. Catling 3359* (DAO, MICH, TRTE and duplicates to be distributed).

Carex suberecta (Olney) Britton

Scoggan (1978, p. 420) alluded to the reports of this species (Soper 1949; Fernald 1950) in southern Ontario and indicated that they were based on collections at MICH from Peach (Peche) Island in the Detroit River (42°20.5′N, 82°56′W). However, he excluded it from the Canadian Flora on the basis of the need for further study.

There are two readily determinable collections from Peach Island in MICH. Both were initially named *C. straminea* Willd. var. *ferruginea* L. H. Bailey, revised to *C. suberecta* by F. J. Hermann in 1959, and confirmed by B. Boivin in 1981. Recently we were able to visit Peach Island as part of a survey of the Detroit River area, and found *C. suberecta* growing along open marshy shores of a narrow bay at the south end of the island. There is an earlier collection of *C. suberecta* in NY from Sandwich, near Windsor. It was recently rediscovered in 1982 at what is probably the same location by M. J. Oldham. Yet another station was discovered by Oldham et al. in 1982 near Harrow.

Carex suberecta differs from other members of the section *Ovales* (in Canada) by the following combina-

tion of features: leaf sheaths green-nerved almost to the summit on the ventral face; leaves less than 2.5 mm wide; pistillate scales awnless and shorter than the perigynia; perigynia 2.1-2.6 mm wide and 4.0-5.0 mm long with the wing very narrow or obsolete basally so that the basal edges are broadly tapered (instead of rounded) resulting in more or less diamond-shaped perigynia (Figure 3). *Carex suberecta* has distinctive narrowly ovoid spikelets due in part to the appressed perigynia. It is a midwestern and southern species of calcareous soils near its northeastern limit in southwestern Ontario.

This species was mapped in Ontario by Ball et al. (1982) but from only one location. All presently known stations are shown in Figure 1.

Specimens examined:

ONTARIO, Essex County.

Sandwich, 18 June 1871, *Henry Gillman* (NY)

Peach Island, Detroit River, 17 June 1893, *C. F. Wheeler* (MICH).

Peche Island, Detroit River, 2 July 1901, *O. A. Farwell* (MICH).

Peach Island, head of the Detroit River, 42°20′N, 82°26′W, 10 July 1981, *A. A. Reznicek & P. M. Catling 3587* (DAO, MICH, duplicates to be distributed).

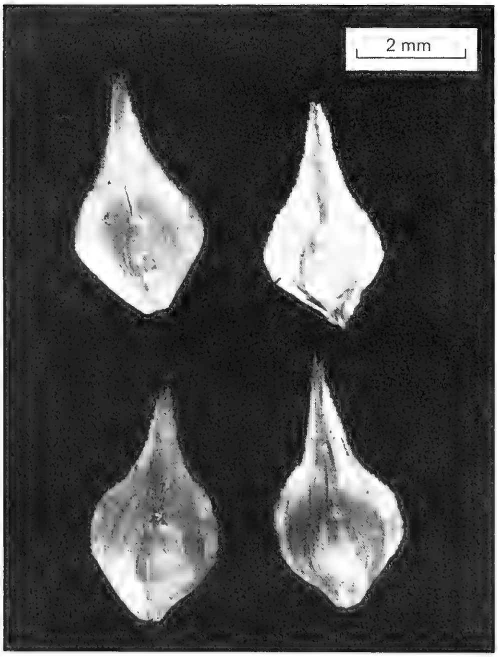

FIGURE 3. *Carex suberecta* (Olney) Britton, perigynia adaxial surface (left) and abaxial surface (right). Ontario, Peach Island, Detroit River, 10 July 1981, *A. A. Reznicek & P. M. Catling 3587* (MICH).

Colchester S. Tp., lots 47 and 48, front conc., UTM 45250, 5 km SE Harrow, "Oxley Poison Sumac Swamp", 12 June 1982, *M. J. Oldham 2742 et al.* (CAN, MICH, TRTE), 22 July 1982 *M. J. Oldham 3081 et al.* (CAN, MICH, TRTE).

Windsor, Ojibway Prairie, N side Titcombe Rd. between Matchette and Malden Streets, 17 June 1982, *M. J. Oldham 2788* (CAN, MICH, TRTE).

Windsor, UTM 307807, S of Spring Garden Rd., W of Huron Church line (Hwy. 3), N of Todd Lane, E of Malden Rd. "Spring Garden Rd. Prairie", 5 July 1982, *M. J. Oldham 2984* (TRTE).

Carex sylvatica Hudson

Widely distributed in Europe and extending into northern Africa and western Asia, *C. sylvatica* has been reported in North America only from Long Island, New York (Mackenzie 1935; Fernald 1950; Gleason and Cronquist 1963). Recent discoveries in Ontario thus represent a significant extension of its North American range as well as the first Canadian records. It was first discovered in Canada in 1971 by S. G. Hay, in Huron County along the Maitland River 2 miles N of Holmesville. In 1977 it was found to be established in deciduous forest at two sites in Oro twp., Simcoe County, northeast of Barrie. In 1980 it was discovered again in Ontario by P. W. Ball, at Queenston Heights, Lincoln County where it grew along a grassy trail through disturbed hardwood forest. It seems evident that the species is well established in Ontario and probably spreading, judging from the number of recent collections. All presently known Ontario stations of *C. sylvatica* are shown in Figure 1.

Carex sylvatica is readily distinguished from the closely related *C. arctata* Boott and *C. debilis* Michx. in being without reddish bases and in having relatively long-beaked perigynia with a more obovoid body abruptly tapered to the beak (Figure 4). The teeth (0.3-0.7 mm long) at the orifice of the perigynia are also relatively well developed in comparison to similar species. The persistent, elongate flexuous stigmas give *C. sylvatica* a superficial resemblance to *C. sprengelii* Dew, but the former differs in having the bract of the lowest pistille spike with a long closed sheath instead of being nearly sheathless. Also *C. sprengelii* has very coarse, prominent, fibrillose culm bases.

Specimens examined:

ONTARIO, Huron County.

Maitland River, 43°41′N, 81°35′W, 2 miles N of Holmesville, 31 Oct. 1971, *S. G. Hay* (CAN, MT).

Simcoe County, Oro twp., lot E, Conc. II, 5 miles

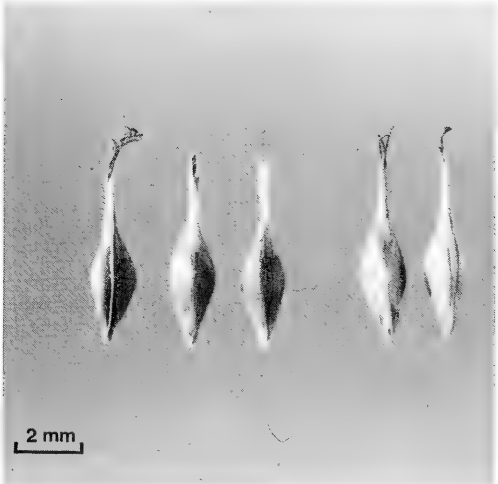

FIGURE 4. *Carex sylvatica* Hudson, perigynia. Left (3). Ontario, Oro Twp., Simcoe Co., 17 July 1977, *A. A. Reznicek 4776 & S. A. White* (DAO). Right (2). Ontario, Queenston Heights, District Municipality Niagara, 11 June 1980, *P. W. Ball 80030* (DAO).

NE of Barrie, 17 July 1977, *A. A. Reznicek 4630 & S. A. White* (MICH).

Oro twp., lot 28, Conc. IV, 6½ miles ENE of Barrie, 17 July 1977, *A. A. Reznicek 4776 & S. A. White* (DAO, MICH, TRT).

Lincoln County, Niagara twp., Queenston Heights, 43°09'N, 79°04'W, UTM grid reference 568797-581802, 11 June 1980, *P. W. Ball 80030*. (DAO, MICH, TRTE).

Fuirena pumila Torrey

Umbrella-grass was predicted as an addition to the Canadian flora by Scoggan (1978, p. 442) on the basis of its nearby occurrence in southern Michigan, but Scoggan was apparently unaware of a specimen collected in the Niagara Peninsula at Port Colborne by J. C. McRae.

Doubt has been cast on the authenticity of some of McRae's Port Colborne collections because two species, *Aristida dichotoma* Michaux and *Fuirena*, were known in Canada only from McRae collections (Dore and McNeill 1980, p. 365). Although McRae's specimens do not have the labels written in his hand, there does not appear to be reason to suspect labelling errors. McCrae collected numerous other interesting species (including many grasses and sedges) in the Port Colborne area. All the species are still present in the Lake Erie region although some are now very rare. In addition, *Aristida dichotoma* was recently rediscovered at Fort Erie, a short distance from Port Colborne (Catling et al. 1977). The regional municipality of Niagara is well known for the occurrence of eastern species (see preceding discussion under *Carex emmonsii*) and suitable habitat for *Fuirena* still exists in the area.

Stations for *Fuirena* in the Great Lakes region are few but well known and widely scattered (Kral 1978). It is known to occur in central Wisconsin (Tans 1982), southwestern Michigan and adjacent Indiana (Deam 1940; Voss 1972), southeastern Michigan (Voss 1972), and northwestern Indiana (Deam 1940). Each of these four areas is separated by about 150 to 300 km; the same distance as between Port Colborne and southeastern Michigan. Thus, McRae's record should not be rejected and has been accepted by Ball et al. (1982). *Fuirena* may still occur in southwestern Ontario and should be sought on moist, open, sandy or peaty flats and shores.

This overlooked record came to our attention in time to be included in the Atlas of Rare Plants (Ball et al. 1982).

Specimens examined:

ONTARIO Regional Municipality of Niagara [Welland County]. Port Colborne, *J. C. McRae*, Aug. 1880, (MTMG; photo DAO, MICH).

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Microhabitat Separation and Coexistence of Two Temperate-zone Rodents

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Morris, Douglas W. 1984. Microhabitat separation and coexistence of two temperate-zone rodents. Canadian Field-Naturalist 98(2): 215–218.

Microhabitat separation of White-footed Mice (*Peromyscus leucopus*) and Meadow Voles (*Microtus pennsylvanicus*) was analyzed within two macrohabitats in Point Pelee National Park. Foliage height diversity, an important predictor of habitat separation by Mice and Voles in macrohabitat studies, was unimportant when the separation was analyzed within habitats. Significant microhabitat separation between White-footed Mice and Meadow Voles reflected macrohabitat preferences, but the separation was dynamic, and no single variable consistently accounted for microhabitat differences. The coexistence of Mice and Voles appears to depend upon microhabitat differences which are maintained despite frequent shifts in microhabitat use by each species.

Key Words: discriminant analysis, habitat selection, microhabitat, *Microtus pennsylvanicus*, Ontario, *Peromyscus leucopus*.

White-footed Mice (*Peromyscus leucopus*) and Meadow Voles (*Microtus pennsylvanicus*) usually occupy different habitat types, but they are occasionally sympatric in ephemeral habitats (M'Closkey and Fieldwick 1975; Morris 1980, 1983). This short-term coexistence suggests that within preferred habitats, site selection by individuals of each species is determined by within-habitat variation. Consequently, the distribution of these species should be predictable by microhabitat, with the result that macrohabitat allopatry is itself an outcome of microhabitat preference.

M'Closkey (1975) reported such an apparent pattern in Point Pelee National Park. Live-trapping censuses of several habitats revealed three distributional patterns of Mice and Voles: White-footed Mice only; Meadow Voles only; and mixed habitats with resident White-footed Mice and transient Meadow Voles. M'Closkey used analysis of variance to demonstrate that pairs of rodent habitats were structurally different in terms of foliage height diversity (FHD), a measure of variation in the horizontal layering of vegetation. White-footed Mice lived in structurally more diverse habitats than the Meadow Voles. This microhabitat separation reflected the different physiognomies of the Mouse and Vole habitats, but revealed little about the importance of FHD as a predictor of Meadow Vole and White-footed Mouse distribution within mutually acceptable macrohabitats.

If local allopatry between White-footed Mice and Meadow Voles is a reflection of microhabitat selection by individuals, and if FHD determines the pattern of habitat separation by mice and voles, then within mixed-species habitats, species separation on the basis of FHD should be maintained. M'Closkey and Fieldwick (1975), in a wet prairie community, analyzed habitat differences between mice and voles by discriminant function analysis, and found significant species separation accounted for by a combination of FHD, tree basal area, and the depth of surface litter. The prairie is far from homogeneous, however, and ranges from "treeless areas of grass to wooded, fern covered localities" (M'Closkey and Fieldwick 1975). The importance of FHD in separating species may be as much the result of physiognomic differences between mouse and vole macrohabitats, as it is the result of an important structural cue to microhabitat selection. The relative importance of these two scales of habitat selection remains unresolved. If microhabitat separation accounts for macrohabitat preference, then similar variables should be responsible for species separation at both scales of habitat analysis.

This report analyzes microhabitat separation between White-footed Mice and Meadow Voles within old field and grassland mixed-species habitats. It asks: Are the patterns of White-footed Mouse and Meadow Vole macrohabitat use consistent with microhabitat separation within macrohabitats? Do the same sets of structural variables consistently account for species separation?

Field Sites and Methods

Small mammals were live-trapped and vegetation structure quantified in grassland, old field, sumac regrowth and deciduous forest habitats in Point Pelee National Park, Ontario (42°00′N, 82°31′W). White-footed Mice resided in both the sumac and forest; Meadow Voles were absent in the sumac and transient in the forest. Both species co-occurred in a 10-yr-old field overgrown with brambles (*Rubus* sp.), goldenrod (*Solidago* spp.) and Tufted Vetch (*Vicia cracca*)

with invading saplings of Ash-leaved Maple (*Acer negundo*) and Red Osier Dogwood (*Cornus stolonifera*); and in a grassland of Wheat Grass (*Agropyron trachycaulum*) with a few young White Pine (*Pinus strobus*) saplings and dense clumps of Black Locust (*Robina pseudoacacia*) suckering from removed parent trees.

In both habitats, single Longworth live-traps were placed at the intersections of a 9 × 15 grid (15 m trap spacings) in the evening, and checked and removed at first light the next day. From 3 May to 10 November 1978, and from 16 May to 29 October 1979, every third line was live-trapped at approximately 10-day intervals, with all 270 stations being trapped six times in each of 1978 and 1979 (810 trap nights in each habitat per year). Each individual captured was identified to species and all rodents were individually marked with metal ear tags, aged, sexed, reproductive status recorded, measured, trap station registered and capture status noted (newly marked or recapture). Animals were released at the point of capture immediately after processing. All soiled traps were washed in detergent and thoroughly rinsed before being reset.

Microhabitat was quantified at all stations. Structural characteristics (two measures each of horizontal profiles, and four of vertical density and surface litter: Morris 1979) were recorded in both 1978 and 1979, and measures of woody perennials (distance in m to the nearest tree, sapling and shrub) as well as shrub numbers within three m, were recorded in 1978. Appropriate data transformations were used where necessary, and all variables were screened for homogeneity (unimodal and symmetrical distribution of scores) and redundancies prior to analysis (Table 1).

Stepwise multiple discriminant function analysis (Wilks method, Klecka 1975) evaluated microhabitat separation within habitats and years. I used a conservative approach where discriminating variables were included in the analysis if they significantly contributed to species separation at $p < 0.05$; they were excluded at $p > 0.025$.

Input for the discriminant analyses were the capture frequencies of each species recorded at each trap station. Species presence could also be used (eg. Morris 1979), but capture frequencies should give a more complete description of the probability density functions of microhabitat use. Before analyzing for differences in microhabitat use, I looked for species differences in residency. If the proportion of transients within a habitat differed between species, the analysis might not detect significant differences in microhabitat as much as it would reflect sampling bias of transient individuals moving through the habitat.

Results

A total of 148 White-footed Mouse and 487 Meadow Vole captures were recorded in the two years of the study (Table 2). Recapture frequencies between species and within habitats and years were similar (Table 2), indicating that the proportion of transient to resident animals was the same for both species. Neither group contributed disproportionately to microhabitat separation by discriminant analysis.

White-footed Mice and Meadow Voles used significantly different microhabitats within each habitat in both 1978 and 1979 (Table 3). In no instance was FHD a significant contributing variable to species separation.

As M'Closkey (1975) predicted, White-footed Mouse microhabitats were structurally more diverse, as measured by FHD, than those of the Meadow Vole (Table 4). The importance of this relationship is overshadowed by voles in the old field occupying areas of greater foliage height diversity than did White-footed

TABLE 1. Quantitative variables used in the analysis of *Peromyscus-Microtus* microhabitat separation in the grassland and old field habitats at Point Pelee National Park.

Variable	Description
Q1	Amount of vegetation from 0–0.25 m
Q2	Amount of vegetation from 0.25–1 m
SUMQ	Total vegetation below 1.75 m
FHD	Foliage height diversity ($1/\Sigma p_i^2$)
AP1	Arcsin proportion vegetation in 0–0.25 m layer
AP2	Arcsin proportion vegetation in 0.25–1 m layer
VERT	Vertical vegetation density from 1.75 m
DVERT	Vertical density diversity among replicate measures
LMAT	Log_{10} mat depth
CMAT	Coefficient of variation of LMAT among replicates
STDEN	Square root of distance to nearest tree > 10 cm dbh
SSDEN	Square root of distance to nearest sapling
SBDEN	Square root of distance to nearest shrub
BUSHN	Square root of shrub numbers within 3 m

TABLE 2. Total *Peromyscus* and *Microtus* captures in equal-sized plots in grassland and old field habitats at Point Pelee National Park. Recapture frequencies are in parentheses.

	Habitat			
	Grassland		Old Field	
Species	1978	1979	1978	1979
Peromyscus	18 (0.44)	18 (0.39)	18 (0.39)	94 (0.59)
Microtus	142 (0.32)	233 (0.37)	39 (0.33)	73 (0.59)

Mice in the grassland. Despite this complexity, there are some patterns in microhabitat preference. White-footed Mice were consistently captured in areas of greater tree and shrub density than were Meadow Voles, even though these differences were not always statistically significant (Table 4).

Discussion

Microhabitat separation within habitats reflected differences in macrohabitat use by mice and voles. White-footed Mouse microhabitats had more total vegetation and greater densities of woody perennials than Meadow Vole microhabitats. Meadow Voles, on the other hand, were captured in areas with more plant litter than were White-footed Mice. The local distribution of White-footed Mice and Meadow Voles seems to depend upon microhabitat selection by individuals. But the pattern of microhabitat selection is not easily defined. No single structural variable was a consistent descriptor of species separation, and compound structural variables may not provide better descriptors of microhabitat differences (Morris, 1980). Discriminating variables may also change in the direction of separation between habitats. In 1979, White-footed Mice in the grassland were caught in microhabitats characterized by a higher proportion of vegetation in the 0.25 – 1 m layer (AP2) than were Meadow Voles. In 1978, however, Meadow Voles in the old field were captured in areas with greater AP2 than were White-footed Mice (Table 4). This likely means that microhabitat selection by individuals is variable, and that patterns of microhabitat use are influenced by the degree of environmental variability encountered in a given macrohabitat.

The tree and shrub density differences demonstrated that within the two mutually acceptable habitats, White-footed Mice were associated with brush and briars, whereas the Meadow Voles were more often found in field openings. The preference of Mice for shrubby and wooded sites, and the Meadow Vole's complementary association with open areas, probably accounts for the usual allopatric distributions of these species.

Previous studies of ecological separation between mice and voles predicted that the two rodent species should occur in microhabitats differing in foliage height diversity. Stepwise multiple discriminant function analysis between these species in the old field and grassland habitats confirmed microhabitat separation, but unlike M'Closkey's results, foliage height diversity was not a discriminating variable. M'Closkey (1975) evaluated structural habitat use across successional habitats. As White-footed Mice are most frequent in shrub and forest habitats, and Meadow Voles are most abundant in open canopy old fields and grasslands, it was predictable that measures of foliage profiles would be different for the two species at this scale of analysis (see also Morris 1984a). The scale of inquiry into habitat separation profoundly affects the outcomes of analyses of habitat separation (Morris, 1984b). Variables responsible for species separation within habitats may not be those same variables which are most capable of separating macrohabitat types.

Variability in microhabitat separation in this study is emphasized in two different ways. First, only one of the discriminating variables was repeated between habitats. Second, even within habitats, discriminating

TABLE 3. *Peromyscus-Microtus* microhabitat separation by stepwise multiple discriminant function analysis in two habitat types in Point Pelee National Park.

Habitat	Year	F-ratio	Discriminating Variables
Grassland	1978	28.03**	LMAT, SUMQ
Grassland	1979	10.42**	AP2, SUMQ, SBDEN
Old Field	1978	6.44*	Q1, AP2
Old Field	1979	24.64**	Q1, BUSHN, STDEN

* $0.01 > p > 0.001$; ** $p < 0.001$

TABLE 4. Mean values of the microhabitat variables used in *Peromyscus-Microtus* separation in grassland and old field habitats at Point Pelee National Park.

	Peromyscus				*Microtus*			
	Grassland		Old Field		Grassland		Old Field	
Variable	78	79	78	79	78	79	78	79
Q1	4.39	4.41	4.01*	3.81*	4.39	4.57	4.36*	4.29*
Q2	1.86	2.54	2.99	2.86	1.62	1.84	3.40	3.09
SUMQ	6.31*	7.01*	8.01	7.79	6.02*	6.69*	8.25	8.03
FHD	1.70	1.84	2.26	2.29	1.63	1.73	2.15	2.15
AP1	57.01	53.01	46.77	46.13	59.31	57.99	47.20	48.22
AP2	32.01	36.57*	37.53*	36.85	30.58	30.38*	39.65*	37.73
VERT**			3.79	4.03			4.42	4.29
DVERT	3.53	3.85	3.83	3.80	3.59	3.65	3.88	3.83
LMAT	0.34*	0.43	0.20	0.36	0.59*	0.42	0.29	0.42
CMAT	53.60	67.44	45.05	52.51	41.29	52.38	60.28	46.89
STDEN	4.94	5.56	4.90	4.98*	5.44	5.63	5.78	5.69*
SSDEN	2.12	2.31	1.21	1.07	2.13	2.18	1.09	0.96
SBDEN	1.08	0.84*	1.15	1.01	1.82	1.80*	1.31	1.23
BUSHN**			2.44	2.65*			2.14	2.02*

*A significant variable in species' microhabitat separation.
**VERT and BUSHN did not meet screening requirements in the grassland.

variable sets were not constant between years, as both vegetation structure and rodent microdistribution changed (Morris, 1980). These results show that microhabitat differences between Mice and Voles occur even within homogeneous habitats, that the separation is not a statistical quirk of heterogeneous sampling, and that the separation is dynamic in space and time. The coexistence of White-footed Mice and Meadow Voles does not result in interspecific competition (Morris, 1983), but appears instead to reflect preferences in microhabitat selection which are different, but malleable and easily shaped to varying environments.

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Influences du dérangement humain et de l'activité du Cormoran à aigrettes, *Phalacrocorax auritus*, sur la reproduction du Grand Héron, *Ardea herodias*, aux îles de la Madeleine

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Drapeau, Pierre, Raymond McNeil, et Jean Burton. 1984. Influences du dérangement humain et de l'activité du Cormoran à aigrettes, *Phalacrocorax auritus*, sur la reproduction du Grand Héron, *Ardea herodias*, aux îles de la Madeleine. Canadian Field-Naturalist 98(2): 219–222.

Une étude de la reproduction du Grand Héron (*Ardea herodias*), réalisée aux îles de la Madeleine (Québec) en 1979 et en 1980, a permis de constater que les interactions avec les Cormorans à aigrettes (*Phalacrocorax auritus*), amplifiées par des dérangements humains fréquents, affectent le succès de reproduction des hérons. En 1979, année de dérangements fréquents, seulement 6 des 17 nids ont mené des jeunes à l'envol; les 11 autres ont été abandonnés avant l'éclosion. La moitié des oeufs pondus (25 sur 49) ont été perdus; 17 l'ont été après la démolition des nids par les cormorans et 8 par la prédation des Goélands à manteau noir (*Larus marinus*) et des Grands Corbeaux (*Corvus corax*). En 1980, année de faible dérangement, seulement un des 14 nids actifs a été abandonné avant l'éclosion. Les taux de survie moyenne des nichées commencées et réussies ont été respectivement de 2,86 et 3,07 jeunes/nid en 1980 par opposition à des valeurs de 0,88 et 2,5/nid en 1979.

Mots clés: Grand Héron, *Ardea herodias*, Cormoran à aigrettes, *Phalacrocorax auritus*, Québec, reproduction, compétition, dérangement humain.

A study of the breeding biology of the Great Blue Heron (*Ardea herodias*), conducted in the Magdalen Islands (Québec) in 1979 and 1980, showed that interactions with Double-crested Cormorants (*Phalacrocorax auritus*), amplified by human disturbance, limit the breeding success of herons. In 1979, when human disturbance was frequent, only 6 of the 17 nests produced fledglings and the other 11 were deserted at the beginning of the breeding activities. Twenty-five of the 49 eggs laid were lost; 17 fell to the ground after the nests had been demolished by Double-crested Cormorants, and 8 were robbed or broken by Common Ravens (*Corvus corax*) and Great Black-backed Gulls (*Larus marinus*). In 1980, when human disturbance was minimal, only one of the 14 active nests was abandoned before the hatching of eggs. On average, 2.86 and 3.07 young herons respectively were produced per active and successful nest in 1980 as opposed to 0.88 and 2.5 in 1979.

Key Words: Great Blue Heron, *Ardea herodias*, Double-crested Cormorant, *Phalacrocorax auritus*, Québec, reproduction, competition, human disturbance.

Jusqu'à présent, peu de travaux ont fait état des interactions interspécifiques chez les Ardeidés aux sites de nidification. Dusi et Dusi (1968) ont observé des agressions entre le Héron garde-boeufs (*Bulbucus ibis*) et l'Aigrette bleue (*Egretta caerulea*) et ils retiennent, entre autres, ce facteur pour expliquer le faible succès de reproduction obtenu par cette dernière. Burger (1978) traite des effets de la compétition entre divers hérons et le Héron garde-boeufs. DesGranges (1980) a vu des Cormorans à aigrettes (*Phalacrocorax auritus*) harceler des Grands Hérons (*Ardea herodias*) et s'emparer de leur nid.

Le présent travail traite de différents aspects de la cohabitation des Grands Hérons et des Cormorans à aigrettes, de ses effets sur la population de hérons et, comme l'ont étudié d'autres auteurs (Conover et Miller 1978; Tremblay et Ellison 1979; Anderson et Keith 1980; Safina et Burger 1983) au sujet d'autres espèces, de l'influence du dérangement humain sur l'activité reproductrice du Grand Héron.

Région d'étude

L'île au Loups Marins, d'une superficie de 14,19 hectares, est située dans le havre de la Grande-Entrée aux îles de la Madeleine (47°38′N, 61°29′W). Elle est recouverte en grande partie d'une forêt de conifères (*Abies balsamea* et *Picea glauca*). La partie non boisée est couverte de graminées (*Ammophila breviligulata*) et d'arbustes (*Ribes* sp., *Rubus* sp.). La végétation arborescente a subi des dommages considérables dus à l'accumulation d'excréments d'oiseaux au sol. Conséquemment, une forte proportion de la forêt est composée d'arbres morts. Il ne reste plus qu'une mince bande de végétation encore saine en bordure de la forêt.

La partie boisée abrite une colonie mixte de Cormorans à aigrettes et de Grands Hérons. Le Goéland argenté (*Larus argentatus*) et le Goéland à manteau noir (*L. marinus*) nichent en petits nombres (moins de 50 couples par espèce) dans la partie non boisée de l'île.

Méthode

La cueillette des données s'est échelonnée sur une période allant de la fin du mois d'avril à la mi-août en 1979 et du début de mai à la fin juillet en 1980. L'examen du contenu des nids a été effectué à l'aide d'un miroir fixé à l'extrémité d'une perche de métal (6 m).

En 1979, nous avons visité la colonie de façon régulière durant la saison de nidification (20 visites). La fréquence de visites fut variable: 1 ou 2/sem. du 30 avril au 27 mai, 3 à 4/sem. du 28 mai au 6 juin, et 1/sem. par la suite jusqu'au 25 juillet. Ces visites duraient environ 1 h mais il est arrivé qu'elles durent 2 h.

En 1980, nous avons réduit le dérangement humain en n'effectuant que 3 visites à l'île aux Loups Marins: une première le 6 mai pour localiser les nids, une seconde le 27 mai pour compter les oeufs et une troisième le 6 juillet pour dénombrer les jeunes. Lors des 2 premières visites, nous ne demeurions près de chaque nid que 2 à 3 min, pour un total de 30 min passées à la colonie. La dernière visite a duré 1 h environ.

Chaque année, en plus des visites, nous avons effectué des observations (totalisant 150 h pour les 2 ans) à partir d'une cache située en périphérie de la colonie mixte. Nous y demeurions du lever au coucher du soleil. Nous ne dérangions les oiseaux qu'à 2 reprises, soit à l'arrivée et au départ. A en juger par l'absence de réactions des oiseaux, il semble que notre camouflage était efficace.

Au cours des visites et des périodes d'observation dans la cache, nos observations ont porté, entre autres, sur les phénomènes suivants: 1) la démolition de nids de héron résultant du pillage des matériaux par des cormorans alors que les propriétaires semblent toujours occuper leur nid; 2) la perte d'oeufs consécutive à la démolition du nid (lorsque les oeufs sont retrouvés intacts et que le nid est détruit); 3) la perte d'oeufs due à la prédation (lorsque les oeufs disparaissent ou sont retrouvés troués et vidés dans le nid ou au sol); 4) l'abandon du nid par les adultes (quand l'activité cesse à un nid sans qu'il n'ait été démoli ou n'ait subi une prédation).

Resultats

Perte de nids et de couvées

En 1979, 11 des 17 nichées commencées par les hérons ont été perdues; les pertes ont surtout eu lieu avant l'éclosion (90,9%), soit du 14 mai au 3 juin. Elles résultent de la démolition de 8 (72,7%) nids par les cormorans, de la prédation de 2 (18,3%) couvées par les Grands Corbeaux et les Goélands à manteau noir et de l'abandon d'un (9%) nid par les adultes sans qu'il y ait eu démolition du nid. Des 49 oeufs pondus par les hérons, 25 (51%) ont été perdus: 17 dus à la démolition de nids par les cormorans et 8 par la prédation des corbeaux et goélands.

En 1980, une seule des 14 nichées commencées par le Grand Héron a été perdue. Comme nos visites furent moins fréquentes qu'en 1979, nous n'avons pas pu déterminer la cause de cette perte. Toutefois, le nid ne semble pas avoir été démoli: lors de la visite du 27 mai, un couple de cormorans y était installé et avait pondu 3 oeufs. Ce transfert a donc eu lieu avant l'éclosion.

Bilan de la reproduction

En 1979, seulement 6 (35%) couples nicheurs ont réussi à faire éclore leurs oeufs, mais chacun d'eux a mené des jeunes à l'envol (Tableau 1). Des 24 oeufs provenant des nichées réussies, 17 ont éclos. Quinze des héronneaux (88%) se sont rendus à l'envol et deux jeunes de la même nichée ont été trouvés morts au même moment à l'âge d'environ 4 semaines. La survie moyenne par nichée réussie fut de 2,5 jeunes par nid, tandis que le nombre moyen de héronneaux produit par nichée commencée ne fut que de 0,88.

En 1980, le nombre de nichées commencées a diminué (14) par rapport à 1979 (17). Par contre, le nombre de nichées réussies a doublé (13) et seulement un nid a été abandonné. Le pourcentage de nichées réussies a donc été très élevé (93%). Mais c'est au niveau de la survie moyenne par nichée commencée que la différence avec 1979 est la plus marquée. En effet, en moyenne 2,86 héronneaux ont été produits par nichée commencée. A notre connaissance, aucun jeune n'est mort au site de nidification avant l'envol.

TABLEAU 1. Succès de la reproduction à la héronnière de l'île aux Loups Marins au cours des étés de 1979 et de 1980.

Année	Nombre de nichées commencées[a]	Nombre de nichées réussies[b]	Nichées réussies %	Survie moyenne des nichées réussies (Nbre de jeunes/nid)	Survie dans les nichées réussies %	Survie moyenne des nichées commencées (Nbre de jeunes/nid)
1979	17	6	35	2,5 (0,83)[c]	88	0,88
1980	14	13	93	3,07 (0,48)	100	2,86

[a]Une nichée est dite commencée lorsqu'il y a eu au moins un début d'activité de la part des nicheurs au nid durant la saison de nidification, peu importe son issue.

[b]Une nichée est dite réussie lorsqu'au moins un jeune de la nichée atteint l'âge d'envol.

[c]Ecart-type.

Discussion

Il importe de préciser que les variations observées du succès de reproduction des hérons ont eu lieu dans une colonie où les effectifs des cormorans ont triplé de 1976 à 1980 alors que ceux des hérons ont diminué de plus de la moitié (Tableau 2). Le succès de reproduction du Grand Héron (survie moyenne des nichées réussies et commencées; voir tableau 1) était, selon la manière de l'exprimer, de 1,3 à 3 fois plus élevé en 1980 (dérangements peu fréquents) qu'en 1979 (dérangements fréquents). Les taux pour l'année 1980 sont comparables à ceux obtenus par d'autres auteurs (McAloney 1973; Quinney 1983) dans des colonies de hérons en milieux côtiers ou marins. Nous sommes donc portés à croire qu'il y a un lien certain entre le faible succès de reproduction observé en 1979 et l'effet perturbateur de la présence humaine; nos visites répétées ont entraîné l'absence prolongée des hérons à leur nid, permettant aux cormorans d'en piller les matériaux et aux goélands de même qu'au corbeaux d'en prendre les oeufs.

Lors de nos premières visites à la colonie les hérons et les cormorans fuyaient à notre approche, mais ces derniers revenaient au nid avant les hérons; par la suite, les cormorans se sont très rapidement habitués à notre présence en demeurant au nid tandis que les hérons sont demeurés sensibles à ces dérangements tout au long de l'étude, quittant leur nid à notre arrivée sur l'île. Thompson (1981) a remarqué que les cormorans s'enfuyaient de la colonie à une distance plus grande de l'observateur que les hérons, mais il ne précise pas si les hérons restaient absents de la colonie plus longtemps que les cormorans.

Divers oiseaux coloniaux sont sensibles aux effets perturbateurs de la présence humaine, notamment avant l'incubation, ce qui entraîne une baisse de leur succès de reproduction (Conover et Miller 1978; Tremblay et Ellison 1979; Milstein et al. 1970). Nos résultats montrent que les Grands Hérons de l'île aux Loups Marins sont sensibles aux dérangements avant et pendant l'incubation.

Les rapports entre les Grands Hérons et les Cormorans à aigrettes varient selon les colonies. Ainsi, Thompson (1981) n'observe pas de compétition entre eux, mais DesGranges (1980) mentionne deux cas où des cormorans ont pris possession d'un nid de héron à la suite d'agressions répétées et de l'absence prolongée des nicheurs. A l'île aux Loups Marins, l'abandon de nids actifs par les hérons semble davantage lié au pillage des matériaux des nids (8 des 11 nids perdus en 1979) qu'à une prise de possession du nid. Les observations de 1979 dans la cache nous ont en effet permis de voir des cormorans s'approprier des matériaux de 5 nids; trois appartenaient à des cormorans alors que les deux autres étaient occupés par des hérons. Ce phénomène a été observé lorsque les nids ont été laissés sans surveillance par leurs propriétaires. Les cormorans prenaient les matériaux et s'en servaient pour consolider leur nid. Les individus pilleurs provenaient autant de nids voisins que de nids éloignés; de là, il apparaît que la répartition des nids pillés n'est pas liée à celle des individus pilleurs. Nous n'avons pas vu un héron prendre les matériaux de nids voisins. En aucun cas nous n'avons été témoins de prédation d'oeufs par les cormorans; les oeufs tombaient au sol lorsque le nid endommagé ne pouvait plus les supporter.

Le pillage des matériaux de nidification et la prise de possession de nid sont des phénomènes qui ont déjà été observés chez d'autres espèces coloniales (Lancaster 1970; Siegfried 1971; Dickerman et Juarez 1971). Considérés comme étant les manifestations d'une compétition que se livrent des individus pour une ressource limitée, ces comportements peuvent avoir des effets sur le succès de reproduction des espèces concernées (Burger 1978). A l'île aux Loups Marins, il

TABLEAU 2. Variations du nombre de couples nicheurs de Cormorans à aigrettes (C.A.) et de Grands Hérons (G.H.) à l'île aux Loups Marins de 1976 à 1980.

	Nombre de couples nicheurs		
Années	C.A.	G.H.	Références
1976	573	35	Mousseau et al. (1976)
1977	728	24	Pilon et al. (1983) et Pilon (communication personnelle)
1978	1000	16	Pilon et al. (1983) et Pilon (communication personnelle)
1979	1289	17	Drapeau (1982) et Léger (communication personnelle)
1980	≅ 1600	14	Drapeau (1982) et Léger (communication personnelle)

est possible que le pillage des matériaux de nid fait par les cormorans résulte d'une compétition entre les individus pour cette ressource car: (1) les nids sont démolis lors des tempêtes d'automne et d'hiver; (2) les matériaux, bien qu'abondants au sol, sous les arbres, ne sont pas accessibles; (3) les individus nicheurs refont leur nid à chaque saison en se procurant les matériaux à l'extérieur de l'île. Toutefois, nous ne pouvons considérer ce phénomène comme l'unique cause du faible succès de reproduction des hérons obtenu en 1979: ce sont nos visites répétées qui ont entraîné l'absence prolongée des hérons à leur nid, fournissant aux cormorans des occasions plus nombreuses de piller les matériaux de leur nid.

DesGranges (1980) croit que la compétition pour les nids que les cormorans livrent aux hérons peut accélérer le départ de ces derniers à un site de nidification. Nos observations nous portent à croire que le pillage de matériaux de nid par les cormorans peut avoir un effet semblable sur les hérons de l'île aux Loups Marins. Cependant, la baisse des effectifs de cette espèce, observée depuis 1977, nous apparaît surtout liée à la détérioration rapide de la végétation arborescente consécutive à l'accumulation des excréments d'une population de cormorans en augmentation (Dusi 1977). Alors que ces derniers s'accomodent bien du dépérissement des arbres (76,9% des arbres porteurs des nids en 1980 étaient secs; C. Léger, communication personnelle), les hérons sont beaucoup moins tolérants à de telles conditions (seulement 4 des 31 nids utilisés en 1979 et en 1980 étaient sur des arbres secs).

En somme, l'activité des cormorans à l'île aux Loups Marins, par la dégradation de la végétation et le pillage des matériaux de nids, entraîne la diminution des effectifs nicheurs de hérons depuis 1976. L'activité humaine, en prolongeant l'absence des hérons aux sites de nidification, amplifie le phénomène de pillage fait par les cormorans et augmente les risques de prédation des oeufs.

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Changes in Small Mammal Communities after Fire in Northcentral Ontario

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Changes in the small mammal community in recently logged upland Black Spruce (*Picea mariana*) and mixedwood stands near Manitouwadge, Ontario, were documented for two to three years after a light fire in early summer and after a severe fire in late summer. Populations on the two burns were remarkably similar in numbers of small mammals and in the composition, diversity, and evenness of the small mammal community. Following fire, Southern Red-backed Voles (*Clethrionomys gapperi*) declined rapidly to rare status and Deer Mice (*Peromyscus maniculatus*) increased within one year to population levels 2–25 times those in unburned stands. Numbers of Masked Shrews (*Sorex cinereus*) declined and numbers of Least Chipmunks (*Eutamias minimus*) increased following the fall fire but not after the spring fire. The diversity and evenness of the small mammal community declined markedly following fire. Deer Mouse populations on the burns showed a greater reproductive performance than those on unburned sites but were similar in most demographic variables to those on new clearcuts. Recent burns may act as dispersal sinks for Deer Mice and provide habitat for colonization.

Key Words: small mammals, Deer Mice, *Peromyscus maniculatus*, Red-backed Voles, *Clethrionomys gapperi*, Masked Shrews, *Sorex cinereus*, Least Chipmunks, *Eutamias minimus*.

The effects of fire on small mammal populations has been extensively reviewed (e.g. Bendell 1974; Kelsall et al. 1977; Ream 1981; Viereck and Schandelmeier 1980). In general, small mammals survive forest fires well and recover quickly. Deer Mice (*Peromyscus maniculatus*) often invade new burns and increase to densities well beyond those in unburned stands, while Southern Red-backed Voles (*Clethrionomys gapperi*) decline to rare status on recent burns. Southern Red-backed Voles and grazing voles (e.g. *Microtus* spp.) may increase in numbers as the vegetation cover becomes re-established. Few studies however, have been conducted on the effect of fire on small mammal populations in the boreal forest and none have examined the demography of small mammal populations after fire. Kelsall et al. (1977), discussing recovery of small mammal populations after fire in northern forests, note: "With shorter breeding seasons, recovery could be considerably slower than reported elsewhere, particularly if fires burned Boreal Forest late in the summer."

I investigated the effects of fire on small mammal populations as part of a study by the Canadian Wildlife Service on the effect of small mammals on Black Spruce (*Picea mariana*) reforestation. The objective was to compare the changes in small mammal populations following fire with those observed following clearcutting (Martell and Radvanyi 1977; Martell 1983a; Martell 1983b). Two extremes of the expected effects of fire on small mammal populations were chosen for study: maximum, a severe fire late in the summer (1975 Burn); and minimum, a light fire early in the summer (1977 Burn).

Study Area

The study area was located on the Ontario Paper Company lease (49° 13′N, 85° 40′W) near Manitouwadge, Ontario, in the Central Plateau Section (B.8) of the Boreal Forest Region (Rowe 1972). The area is underlain by granite bedrock, with pockets of sand and gravel, and soils are generally very thin. Upland sites support mature stands of Black Spruce with a small component of Jack Pine (*Pinus banksiana*), Paper-birch (*Betula papyrifera*), and Aspen (*Populus tremuloides*). Dry knolls support mixed stands of Aspen, Paper-birch, White Spruce (*Picea glauca*), and Balsam Fir (*Abies balsamea*) while wet, lowland sites support stands of Black Spruce with a small component of White Cedar (*Thuja occidentalis*). One of the study areas (1975 Burn) was an upland Black Spruce site which was clearcut in the summer of 1975, leaving slash and a few patches of residual mixedwood. The area burned in August 1975 (fire number TER–21–75) with a slow, hot fire that removed almost all of the moss layer leaving only material soil. The second study area (1977 Burn) was an upland mixedwood site selectively harvested for spruce during the winter of 1976–77. The area burned in early June 1977 (fire number TER–15–77) with a fast fire that left some trees and the moss layer only scorched.

Methods

Population indices (catch per 100 trap nights) were based on the number of captures on trap lines consisting of 25 trapping points at 15 m intervals. A Museum Special and either a Victor or a Holdfast trap were placed separately within 1 m of each point and baited with a mixture of rolled oats, peanut butter, and rendered bacon fat. Lines were left for 72 h and checked three times at 24 h intervals. Trapping was conducted in early September 1975 and at intervals from early May through early October 1976–1978 (see Martell 1983a for details).

Standard measurements (total length, tail length, hind foot length, ear length, total weight) were taken on all captures, they were examined for the presence of botfly larvae or larval scars, and the skin was removed and examined for the presence of wounds. Testes length was measured and epididymal smears were made to check for the presence of sperm. Female reproductive tracts were examined and the number of embryos and (or) placental scars, if present, was recorded. Deer Mice were assigned to age classes on the basis of body weight as follows: juveniles 12 g or less, subadults 13–16 g, adults 17 g or more. Voucher specimens of all species of small mammals caught were placed in the National Museum of Natural Sciences, Ottawa.

Differences in numbers were compared by t-test and in proportions by Chi-square test following Sokal and Rohlf (1969) and Siegel (1956). Statements of significance refer to the P = 0.05 level or better. Percentage similarity (Pielou 1975) was calculated for study areas and years. Diversity and evenness of the small mammal communities was calculated using Brillouin's index (Pielou 1975).

Results

The 1975 Burn was first trapped about one month after the fire and only one Deer Mouse and one Southern Red-backed Vole were captured (a total of 1.3/100 trap nights). By September 1976, however, the population of Deer Mice had increased to 13.3/100 trap nights and a small mammal community had established itself on the 1975 Burn. Based on percentage similarity as an index, that community, from 1976 to 1978, was much more similar among

TABLE 1. Relative numbers (number/100 trap nights) of small mammals in burned and unburned stands near Manitouwadge, Ontario, 3 May — 8 October, 1975–1978. Mean ± one standard error is presented. Number of trap lines in parentheses.

Species	Unburned Black Spruce 1975–78 (21)	1975 Burn 1976–78 (12)	Unburned Mixedwood 1976–78 (45)	1977 Burn 1977–78 (4)
Sorex cinereus	1.1 ± 0.41	0.1 ± 0.09[b]	1.3 ± 0.23	1.7 ± 1.26
Sorex fumeus	tr[a]	—	—	—
Sorex arcticus	tr	—	tr	—
Microsorex hoyi	0.1 ± 0.08	0.1 ± 0.08	tr	—
Blarina brevicauda	0.2 ± 0.08	—	0.6 ± 0.13	0.3 ± 0.32
Total shrews	1.4 ± 0.53	0.2 ± 0.10	1.9 ± 0.26	2.0 ± 1.59
Peromyscus maniculatus	0.5 ± 0.20	12.7 ± 1.85[c]	4.0 ± 0.46	10.3 ± 2.65[e]
Clethrionomys gapperi	2.1 ± 0.47	0.1 ± 0.06[d]	2.8 ± 0.42	—
Phenacomys intermedius	tr	—	tr	—
Microtus pennsylvanicus	—	0.1 ± 0.06	—	—
Microtus chrotorrhinus	0.1 ± 0.06	—	0.2 ± 0.09	0.2 ± 0.17
Synaptomys cooperi	tr	—	—	—
Zapus hudsonius	tr	0.1 ± 0.11	tr	—
Napeozapus insignis	—	—	0.1 ± 0.05	—
Total mice and voles	2.8 ± 0.53	12.9 ± 1.85[c]	7.1 ± 0.54	10.5 ± 2.54
Tamias striatus	—	—	tr	—
Eutamias minimus	0.1 ± 0.07	1.1 ± 0.31[c]	0.6 ± 0.16	0.3 ± 0.32
Total small mammals	4.3 ± 0.84	14.2 ± 2.08[c]	9.6 ± 0.69	12.8 ± 3.79
Diversity (bits)	2.09	0.61	2.28	0.88
Evenness	0.61	0.23	0.65	0.41

[a]tr = < 0.05/100 trap nights
[b]significantly different from 1977 burn, $p < 0.05$
[c]significantly different from unburned Black Spruce, $p < 0.001$
[d]significantly different from unburned Black Spruce, $p < 0.01$
[e]significantly different from unburned mixedwood, $p < 0.001$

years (82%) than to either the small mammal community one month after the fire (9%) or to that in unburned Black Spruce stands (7%). Compared to unburned Black Spruce stands, the 1975 Burn had significantly more Deer Mice and Least Chipmunks (*Eutamias minimus*) and significantly fewer Southern Red-backed Voles (Table 1). There were also significantly more small mammals in total on the 1975 Burn, but the diversity and evenness of the small mammal community were markedly reduced.

The 1977 Burn was first trapped about 10 d after the fire and numerous smouldering "hot spots" were still present. A total of 5.3 Deer Mice/100 trap nights were captured, a number similar to that captured at the same time a year later. The small mammal community on the 1977 burn in 1977 and 1978 was as similar between years (80%) as it was to the 1975 Burn (77%), but was much less similar to that in unburned mixedwood stands (49%). Compared to unburned mixedwood stands, the 1977 Burn had significantly more Deer Mice (Table 1). Diversity and evenness of the small mammal community were markedly reduced on the 1977 Burn relative to that in unburned mixedwood stands. Numbers of most species of small mammals were similar between the two burns, but the 1977 Burn supported significantly more Masked Shrews (*Sorex cinereus*) than did the 1975 Burn (Table 1). Diversity and evenness of the small mammal community on the burns were more similar to each other than to those in unburned stands.

Only Deer Mice occurred in sufficient numbers on the burns to allow me to examine their demography. A significantly greater proportion of females were breeding on burned than unburned sites, yet the proportion of young-of-the-year was significantly lower (Table 2). Also, none of the Deer Mice captured on burns were infested with botfly larvae in contrast to those from unburned sites (Table 2).

Discussion

The pattern of decrease in numbers of Southern Red-backed Voles and increase in numbers of Deer Mice that I observed on both burns is consistent with that observed after fire in other conifer and mixedwood stands (Ahlgren 1966; Gashwiler 1959, 1970; Halvorson 1981; Krefting and Ahlgren 1974; Sims and Buckner 1973). The main difference between the burns was the decline in Masked Shrews and the increase in Least Chipmunks on the 1975 Burn. Chipmunks have been reported to show an immediate decrease in numbers and then a gradual increase after fire in other conifer stands (Ahlgren 1966; Gashwiler 1959, 1970; Halvorson 1981; Hooven 1969), which has been suggested to relate to the availability of seeds. Deer Mice ate proportionally more seeds and berries on the 1975 Burn than on the 1977 Burn (Martell and Macaulay 1981), possibly reflecting the availability of those foods. If so, the increase in the number of Least Chipmunks on the 1975 Burn may also have been in response to food. However, food availability does not easily explain the low numbers of Masked Shrews on the 1975 Burn because arthropods were available as a major food item of Deer Mice on both burns (Martell and Macaulay 1981).

The pattern of change in the composition of the small mammal community after fire is also similar to

TABLE 2. Some demographic attributes of Deer Mice (*Peromyscus maniculatus*) in burned and unburned stands, 1976–1978. Sample size in parentheses. Significance of differences between stands is indicated.[a]

Attribute	Burned	Unburned
1. Proportion of young-of-the year[b] (13 June–8 October)	0.69 (258)	0.79 (593)**
2. Proportion of males	0.57 (281)	0.54 (632)
3. Proportion of males with sperm:		
— all males (3 May–4 August)	0.64 (85)	0.52 (160)
— subadults and adults (5 July–4 August)[c]	0.58 (40)	0.46 (80)
4. Proportion of females with embryos or placental scars:		
— all females (3 May–8 October)	0.45 (121)	0.33 (288)*
— subadults and adults (5 July–8 October)[c]	0.65 (57)	0.42 (174)**
5. Number of embryos (mean ± standard error)	5.4 ± 0.21 (20)	5.4 ± 0.16 (19)
6. Proportion showing wounds on the pelt	0.04 (280)	0.04 (632)
7. Proportion infested with botfly larvae (26 July–8 October)	0.00 (189)	0.08 (382)***

[a]significance: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$
[b]juveniles and subadults
[c]all juveniles were immature

that observed on clearcuts (Martell 1983a; Martell and Radvanyi 1977), but the change occurred much more rapidly on the burns (1 yr) than on the clearcuts (3 yr). Unlike the changes observed on the burns, however, diversity and evenness of the small mammal community may increase or remain stable in the first 1-3 years following clearcutting (Martell 1983a).

Populations of Deer Mice on burned sites compared to those on unburned sites showed an increase in reproductive performance but a lower proportion of young-of-the-year (juveniles and subadults). However, because age determination was based on body weight, young-of-the-year with high growth rates could have been classified as "adults" by the end of the summer. The low proportion of young-of-the-year on the burns, therefore, may be a result of high growth rates or due to a greater influx of adults from surrounding, unburned areas. In general, the demographic attributes of Deer Mice on burns are consistent with those of presaturation dispersers as defined by Lidicker (1975).

The demography of Deer Mice on the burns was remarkably similar to that on recent clearcuts (Martell 1983b). There was no significant difference between populations from burns and clearcuts in the proportion of young-of-the-year, the proportion of males, the proportion of males and females breeding, litter size, or the proportion wounded. However, significantly fewer ($P < 0.05$) Deer Mice were infested with botfly larvae on the burns than on clearcuts. As with clearcuts, burns may serve as dispersal sinks for Deer Mice (Martell 1983b).

Contrary to the suggestion of Kelsall et al. (1977), recovery of Deer Mice after fire occurred rapidly, in fact more rapidly than after timber harvest. Even severe fire, therefore, leaves a habitat that can be exploited by a generalist such as the Deer Mouse.

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The Canadian Beaver, *Castor canadensis,* as a Geomorphic Agent in Karst Terrain

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Cowell, Daryl W. 1984. The Canadian Beaver, *Castor canadensis,* as a geomorphic agent in karst terrain. Canadian Field-Naturalist 98(2): 227–230.

The karst drainage of a Beaver-occupied lake (Bruce Peninsula) and a sinkhole pond (Hudson Bay Lowland) resulted in dam and canal building by Canadian Beavers (*Castor canadensis*). The Beavers were unsuccessful in maintaining their habitat. Their activities probably enhanced karstification.

Key Words: Canadian Beaver, *Castor canadensis,* karst drainage, sinkholes, peat canals

The Canadian Beaver (*Castor canadensis*) is a widespread species whose range encompasses a variety of terrain types. These include the gently undulating till plains of southern Canada, the bedrock controlled hills of the Canadian Shield, the mountains of the western Cordillera and eastern Appalachia, and flat-lying coastal plains and peatlands such as the Hudson Bay Lowland. Their survival depends on their unique ability to find or engineer ponds with sufficient depth as not to freeze to the bottom. In terrain characterized by surface drainage networks, this does not present a problem. Beaver dams create ponds which, with regular maintenance, can last many years before they are filled-in by aquatic vegetation and organic and mineral sediments. However, in areas underlain by carbonate bedrock such as limestone or dolomite, surface waters may be captured by underground stream channels creating special problems for the beaver.

The process of carbonate solution by natural waters is known as karstification and produces a suite of landforms known as karst. These include surface forms, such as micro-etching (karren) and sinkholes, and subsurface caves. In young karst terrains, such as the Bruce Peninsula of southern Ontario, solution caves are relatively small and physical exploration is limited. They are, however, being actively enlarged by permanent or seasonal streams. In older karst areas dry relict caves and active "wet" caves may co-exist. These often have much explorable passage as occurs in the eastern Canadian Rockies and central Kentucky.

Natural subterraneous plumbing systems generated by karst processes create opportunities as well as problems for man and wildlife. For man, opportunities include domestic water supplies and sewage removal. However, all too often man's experience with karst systems, particularly in urban settings, creates more problems than opportunities. These include severe flooding, as the capacity of the caves to pass urban runoff is exceeded, and surface subsidence and collapse where the lowering of groundwater levels for domestic supplies removes buoyancy support from large caves.

Opportunities for migratory birds, Beavers and other wildlife arise from blocked sinkholes creating natural ponds, marshes or small lakes. These may become permanent features if the blockage is complete and the cave is not further enlarged by waters captured upstream. More often, these ponds are temporary, especially in young karst terrains where older, established surface drainage systems are being captured. Two examples of direct effects on beaver habitat by active underground capture are described here. The first is on the dolomite plain of the Bruce Peninsula in southern Ontario. The second is in the Hudson Bay Lowland of northern Ontario on peatland-covered limestone.

The Bruce Peninsula is an actively developing karst terrain characterized by a number of sinking streams and lakes connected to springs by shallow cave systems (Cowell 1976; Cowell and Ford 1980, 1983). Within Cyprus Lake Provincial Park two lakes are connected by a joint-controlled cave which is too small for exploration (Figure 1). Horse Lake is a shallow lake on bedrock situated at 45° 13′N, 81° 35′W. It's level is currently controlled by sinkholes along the northwest shore. Subsurface drainage connects Horse Lake with Marr Lake, 375 m to the northwest. The underground connection lies beneath a former bay of Horse Lake which likely drained across a low ridge into Marr Lake. Two large sinkholes, now inactive except during snowmelt, occur in the lowest portion of this former bay. Prior to the formation of these sinks Horse Lake must have had a relatively stable water level. The overburden in this area is extremely shallow and water eventually began to drain through the rock at several points in this former bay. After an unknown period the bay was completely drained by

the cave system. The water level of Horse Lake was controlled by the sinkholes. Remains of a beaver dam occur above the largest sinkhole at the edge of the present lake (Figure 1). This sinkhole is currently about 2.5 m deep and up to 20 m wide. The placement of the dam around the edge of this sinkhole, closing-off a small channel which drains into the sink indicates that draining of the lake through these sinks predates the dam. It is not known if Beavers dammed the bay as it receded toward the centre of the lake. The dam stopped drainage into the large sinkhole and probably raised the level of the lake above current late summer levels. Continued subsurface drainage around the dam, however, eventually forced the Beavers to abandon Horse Lake.

The Hudson Bay Lowland is a flat coastal plain which is characterized by extensive peatland terrain. The peat is underlain by till, Tyrrell Sea marine deposits and sedimentary bedrock. Limestone is the most common rock type and in places it directly underlies peat of variable thickness. One such area occurs along the Attawapiskat River centred about 90 km west of James Bay at 52° 52′N, 83° 44′W (Figure 2). This area has been referred to as the Attawapiskat Karst by Cowell (1981, 1983). The area consists of a complex of low limestone knolls representing ancient coral bioherms. They are surrounded by a mature bog and fen complex having up to 1.5 m of peat accumulation. Surface karst processes are concentrated at the interface between peatland and the reef knolls where numerous large sinkholes have developed. Subsurface capture at the sinkholes has lowered the water table in the surrounding peatlands slowing peatland development in the immediate area and initiating degradation of the organic blanket nearest to sinkpoints. The karst is very young (estimated to be less than 4400 years old) and many sinkholes drain completely only during the driest years.

I visited the area in July 1977 and observed a particularly interesting reef knoll located to the north of the Attawapiskat River. The reef surface lies at about the same level as the surrounding bog and occurs between two lakes. The reef supports aspen and spruce (*Populus tremuloides* and *Picea glauca*) although most of the mature aspen have been felled by Beavers. Aerial photographs, taken in August 1970, show the reef almost completely surrounded by open water. When the site was examined in the field most of the water had drained into a sinkhole on the north side of the reef.

A small remnant pond located to the south of the reef was connected to the sinkhole by a narrow channel cut into the exposed peat (Figure 3). An abandoned beaver lodge and food pile were found in the sinkhole on the north side of the reef. Another peat canal brought a trickle of water into the sink from the northwest (Figure 2).

The most interesting aspect of this site is the relationship between karst drainage and Beaver activity. The Beavers built a fairly extensive canal system in response to lowering water levels in their pond. The

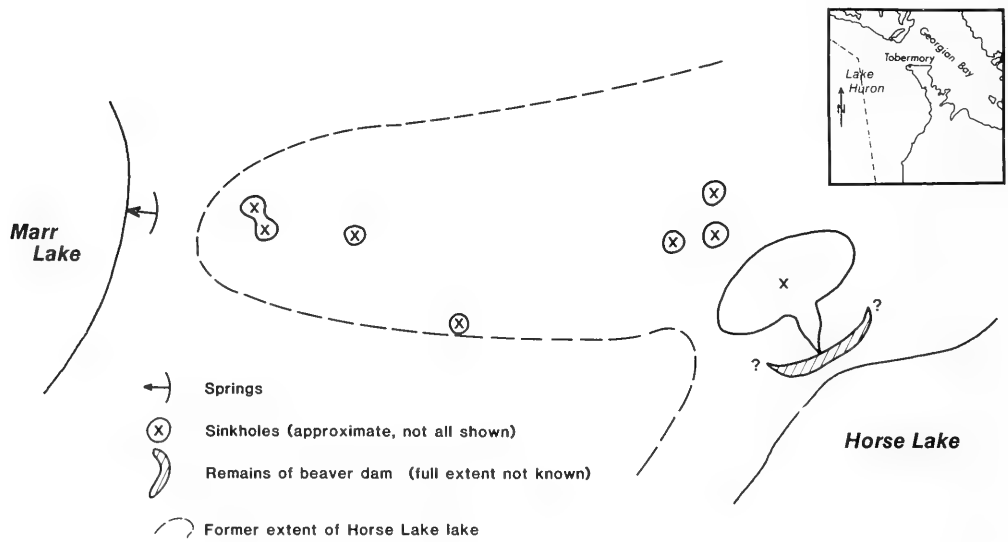

FIGURE 1. Sketch diagram of karst and Beaver dam between Horse and Marr lakes, Bruce Peninsula, Ontario.

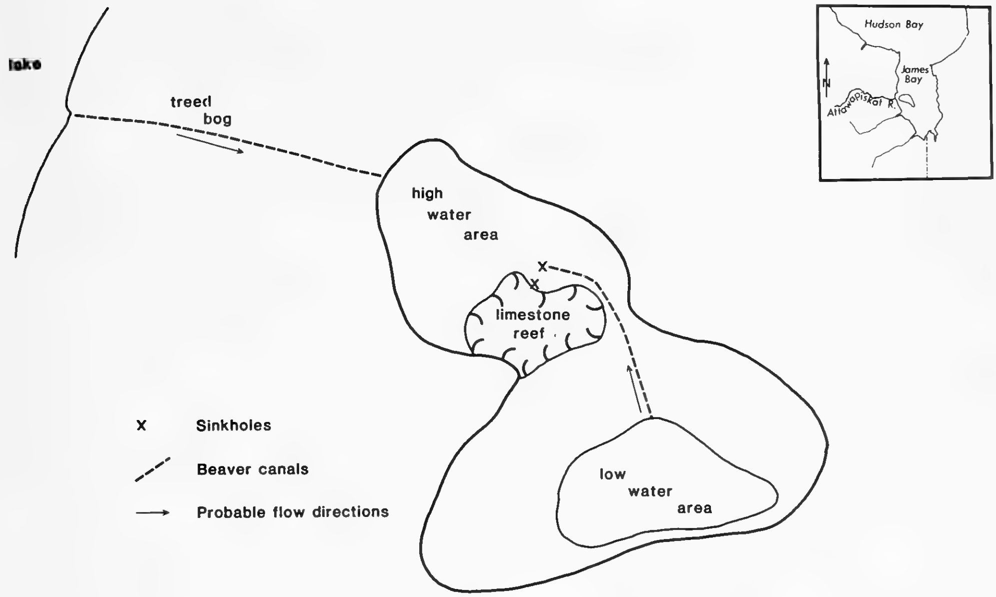

FIGURE 2. Sketch diagram of karst and Beaver canals at limestone reef within peatland complex, Attawapiskat River, Ontario.

channel between the sinks and the small pond to the south was not naturally cut by running water. It occupies a flat portion of the former lake bed with little or no change in relief from one end to the other. The sinks took the extra water which this canal delivered without raising the level of the pond. The Beavers then dug a second channel approximately 1.0 m deep and about 160 m long through the treed bog to the northwest to connect with the large lake (Figure 2). However, any additional water delivered by this canal was also taken by the sink. After failing to block the sinks the Beavers finally abandoned the area.

In these examples the Beavers were unsuccessful in maintaining their habitat requirements in karst terrains. In attempting to regulate water levels within and adjacent to sinkholes, they became agents of karstification by providing more water for underground capture.

FIGURE 3. Beaver canal dug into exposed peat of former lake which surrounded a limestone reef (at left) in Hudson Bay Lowland. The sinkhole is located at centre behind the figure. The second canal drains through the treed bog in the background.

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The Biological Flora of Canada
4. *Shepherdia argentea* (Pursh) Nutt., Buffaloberry

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Looman, J. 1984. The Biological Flora of Canada. 4. *Shepherdia argentea* (Pursh) Nutt., Buffaloberry. Canadian Field-Naturalist 98(2): 231–244.

Shepherdia argentea (Pursh) Nutt., Buffaloberry, is a usually armed shrub or small tree which occurs primarily along streams and lakeshores, and in coulees and ravines of the southern parts of the Prairie Provinces where it appears to be limited to altitudes below about 1000 m. Commonly, it forms more or less dense shrub communities with up to eight other species in dry-mesic sites, and up to 10 species in mesic sites. Flowering begins from late April to early May and berries ripen in late July to mid-August. Percentage germination in fresh seed varied from 26% to 76% but negative reproduction appears to be more important in present distribution. Plains Indians used the berries both fresh and dried; at present it is occasionally used for jams, jellies and wine.

Key Words: *Shepherdia argentea,* Buffaloberry, Bull berry, grains de boeuf, biology, ecology, phenology, distribution economic importance.

1. *Name*

Shepherdia argentea (Pursh) Nutt., Elaeagnaceae (Pursh 1814; Nuttall 1818; Plate 2, p. 240).
Buffaloberry, Thorny buffaloberry, Bull berry, grains de boeuf.
Hippophaë argentea Pursh (Pursh 1814: 1, p. 115).
Elaeagnus utilis Nels., (Nelson 1935: p. 682).

Shepherdia is one of three genera in the Elaeagnaceae occurring in North America.

2. *Description of the Mature Plant*

(a) *Raunkiaer life-form and perennation: Shepherdia argentea* belongs to the Phanerophyta (Ellenberg and Mueller-Dombois 1965/66), which include woody plants with the leaf-buds more than 25 to 50 cm above the ground. In this terminology, *S. argentea* is a summergreen microphyllous microphanerophyte within the group of phanerophytes, i.e., with stems 2 to 5 m high, and deciduous leaves usually less than 5 cm^2 in area. Plants are long-lived; I have seen shrubs of 50 to 60 years old, and many individual stems are 20 to 25 years old (Figure 1). Old stems may be replaced by young stems upon death; I have noted root-crowns considerably older than the stems arising from them.

(b) *Shoot Morphology: Shepherdia argentea* is usually shrubby, or occasionally a small tree, 2 to 5 m high, with stems to 10 cm diam., and many-branched. The branchlets often end in hard sharp spines 4 to 5 cm long (Figure 2). Branchlets are opposite; the bark is silvery scurfy when young, becoming greyish-brown in the third or fourth year. Leaves opposite, 2 to 5 cm long, 0.5 to 1.5 cm broad, the margins entire, sometimes involute, with petioles 0.5 to 1.0 cm long. Leaf surfaces covered with lepidote hairs, consisting of closely arranged, strap-like refractive threads, forming a peltate 'scale', 0.1 to 0.25 cm in diameter (Figure 3c).

(c) *Root Morphology:* The root system of *S. argentea* is complex. Individual stems may arise from a root-crown, which forms a thickening at the apex of a taproot, or in a rootstock. The root-crown usually exceeds the stem or stems arising from it in diameter. Several rootstocks may branch off from a root-crown, spreading in several directions at a depth of 10 to 15 cm below the soil surface. Rootstocks can reach a diameter of 15 mm, and reach a considerable length, sending up shoots at intervals of about 40 to 50 cm. Sinker roots are formed at irregular intervals, often near shoots, but also between shoots; they penetrate to 80 cm or more into the soil. The entire root system has a smooth greyish brown bark, and forms rootlets and root hairs only sparingly, mostly concentrated near the stems.

(d) *Inflorescence: Shepherdia argentea* is dioecious. Flowers occur singly or in small clusters in the leaf axils of second year wood, and are apetalous. The staminate flowers have a disk with four sepals and eight stamens, alternating with the lobes of the disk; the sepals are scurfy on the back, 1 to 1.25 mm long; the filaments of the stamens are shorter than the sepals; the anthers about 0.5 mm long, bilocular (Figure 3a). The pollen grains are

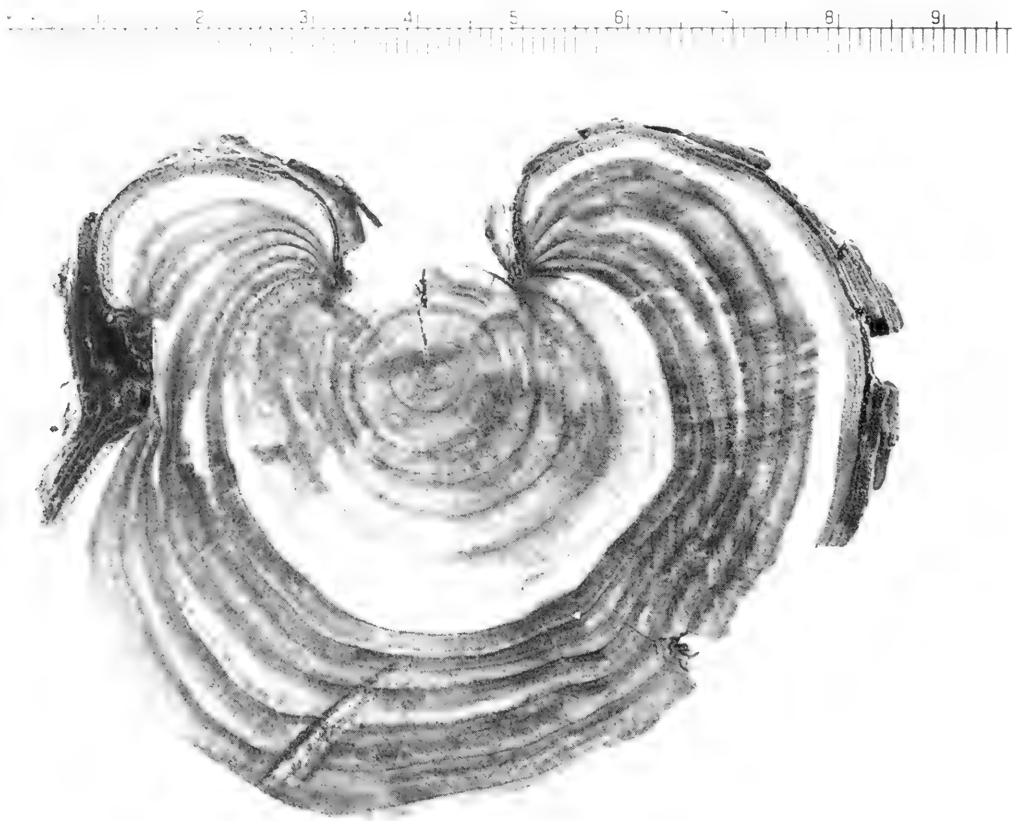

FIGURE 1. Cross-section of stem of *Shepherdia argentea;* small tree, about 4 m tall. The scars are caused by browsing on the bark, the deep one at about 9 years of age, the shallow one at about 14 years of age.

pyramidal, 0.03 to 0.04 mm on the sides, tricolporate (Figure 3d). The pistillate flowers are urceolate below, the tube 0.5 to 1.0 mm long; the upper part has four lobes, densely hairy at the throat of the tube; the ovary is short cylindric, the style about 0.7 mm long, the stigma elliptic, placed at an angle to the style (Figure 3b).

(e) *Subspecies:* None have been described.

(f) *Varieties:* None. The species appears to be very uniform throughout its area of distribution.

(g) *Ecotypes:* No evidence of ecotypic variation has been noted.

(h) *Chromosome number:* 2n = 26 (Darlington and Wylie 1955; Arohonka and Rousi 1980); 2n = 22 (Löve and Löve *in* Löve 1982).

The genera and native species in the Elaeagnaceae occurring in Canada can be distinguished as follows:

(1) Plants monoecious; fruits mealy, silvery scurfy	*Elaeagnus commutata*
Plants dioecious; fruits not mealy, yellowish to red	(2)

FIGURE 2. Branch of *Shepherdia argentea.*

(2) Leaves alternate	*Hippophaë rhamnoides*
Leaves opposite	*Shepherdia* (3)
(3) Shrubs thorny; leaves silvery on both surfaces	*S. argentea*
Shrubs not thorny; leaves green on upper surface	*S. canadensis*

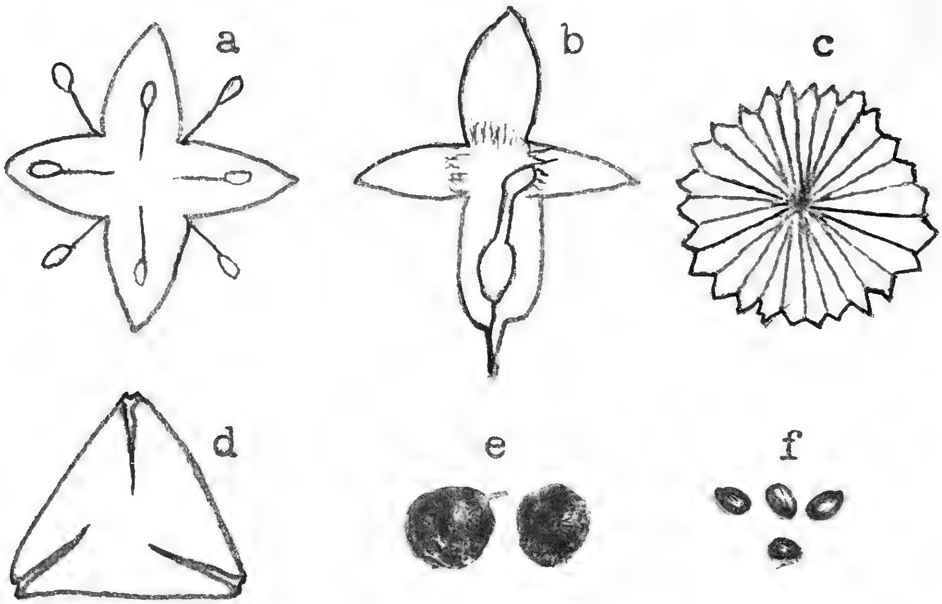

FIGURE 3. (a) male flower; (b) female flower; (c) lepidote hair; (d) pollen grain; (e) berries; (f) achenes. Scales: (a) and (b) 12x; (c) 400x; (d) 1000x; (e) 3x; (f) 2x.

3. *Distribution and Abundance*

(a) *Geographic range:* In Canada, the species is limited to the Prairie and southern parklands of the Prairie Provinces (Figure 4). The distribution given for Alberta by Scoggan (1977)—"N to Medicine Hat"—is incomplete; I have collected the species at Drumheller. It is most abundant in southwestern Saskatchewan and southeastern Alberta; in other parts of the Prairie Provinces it is much less frequently encountered, but can be locally abundant. In the USA, it occurs in the Great Plains, east to Minnesota and Iowa, and south to New Mexico (Great Plains Flora Association 1977).

(b) *Altitudinal range: S. argentea* appears to be limited to altitudes below about 1000 m in the Prairie Provinces. The species occurs between 900 and 1000 m altitude in southwestern Alberta, and in the Wood Mountain area in Saskatchewan. In eastern Manitoba it occurs at altitudes of about 250 m.

4. *Physical Habitat*

(a) *Climatic relations:* Within the area of its distribution, *S. argentea* appears to be indifferent to variations in climate, and occurs over the entire range of temperature and precipitation prevailing in the southern Prairie Provinces.

(b) *Physiographic relations: Shepherdia argentea* is most common in a rather well defined habitat-type that can be described as: non-saline to slightly saline, often somewhat calcareous soils with a narrow pH range (Table 1) of sandy loam to sand textures; usually poorly drained and gleyed, classed as "carbonated" gleysol, or in the parklands, humic gleysol (National Soil Survey Committee 1974). Within this habitat-type distinction can be made between dry-mesic, mesic, and wet-mesic sites.

In the southern prairies and in the parklands the habitat-type is commonly associated with river or creek banks (Figure 5), or with low-lying, somewhat marshy areas. Occasionally, solitary shrubs or small clumps of shrubs are found on apparently dry slopes. However, such sites are usually found to have a water table at a shallow depth.

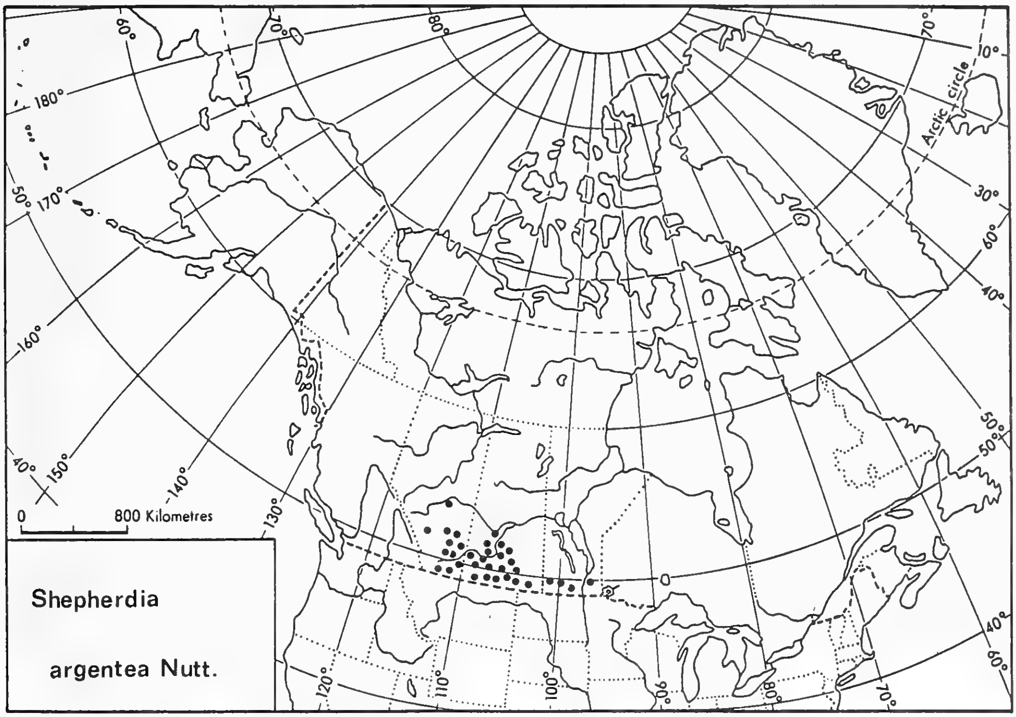

FIGURE 4. Canadian distribution of *S. argentea* from specimens of the Herbaria: University of Alberta, Edmonton (ALTA); University of Calgary (UAC); W. P. Fraser, University of Saskatchewan, Saskatoon (SASK); Research Station, Swift Current (SCS); Department of Agriculture, Ottawa (DAO).

TABLE 1. Ranges and averages of soil characteristics of *Shepherdia argentea* stands in Table 3.

	pH	Ec	N-NO_3	P	Cl	Na	K	Ca	Mg
High	7.71	6.80	344.4	35.2	78.0	430.0	109.0	960.0	720.0
Low	6.29	0.41	0.4	2.6	4.5	3.0	16.0	45.0	7.0
$\bar{x}$	7.21	1.41	17.7	7.2	15.5	37.2	46.3	153.0	76.0
0 –	0.36	0.68	27.0	3.0	7.3	42.3	8.6	70.0	72.0

Ec (Electrical conductivity) in mmhos/cm; elements in ppm. Determinations: N, P: Hamm et al. 1970; Ca, Mg by atomic absorption; Na, K by flame photometer, Procedure Manuals.

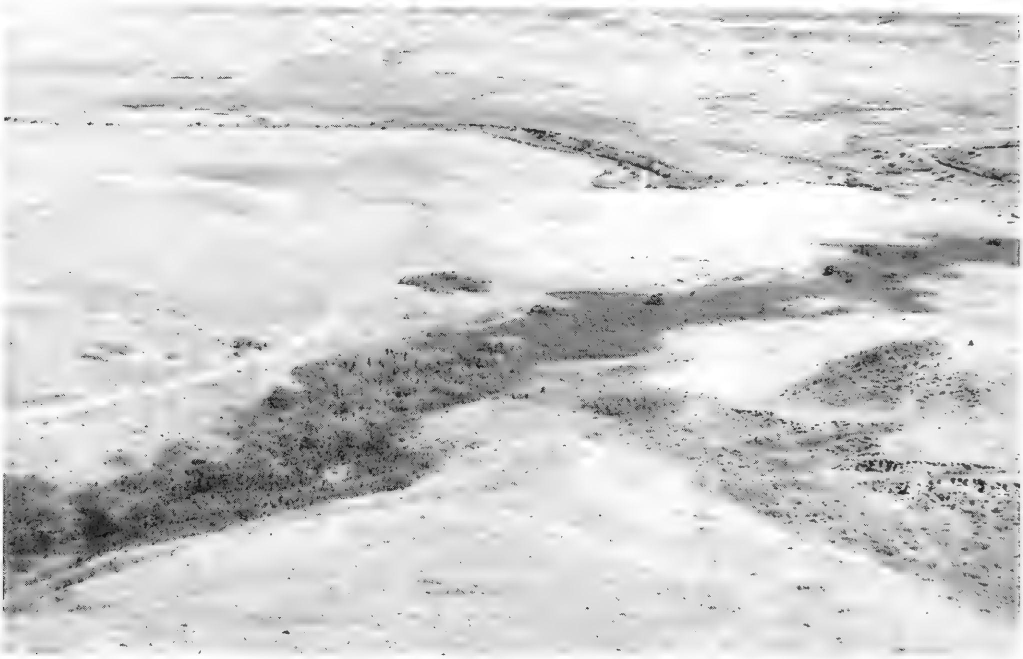

FIGURE 5. Distribution of *Shepherdia argentea* in the landscape; Frenchman River valley northeast of Climax, Saskatchewan.

(c) *Nutrient and water relations:* The very wide range of nutrient status in the sites where *S. argentea* occurs (Table 1) seems to warrant the conclusion that the level at which major nutrients are present is not critical for the development of the species at any one time. For example, in the areas of stands 12 and 23 (Table 2), in each of which several stands were sampled intensively along transects, levels of each nutrient show a range of 3:1, or more. At the same time, lowering of the water table through prolonged drought caused stress, shown by wilting of the leaves. Recovery after heavy rains was rapid, however.

5. *Plant Communities*

Shepherdia argentea can occur as solitary shrubs, but more commonly the species forms more or less dense shrub communities in which several woody species are represented. In dry-mesic sites the total number of species may reach seven or eight, and the herbaceous cover is scant. In mesic sites the communities can be well-developed, with as many as 10 species of shrubs or small trees represented, and a well-developed ground cover. In wet-mesic sites species of *Salix* are usually present in the shrub layer, and several wetland herbs appear in the ground cover. There are indications that succession can occur, and eventually results in "gallery forest", in which *Populus* spp. are dominant. In several areas along the South Saskatchewan River and Red Deer River (Alberta) such forests occur with *S. argentea* as an important constituent of the shrub layer. A summary of plant communities with *S. argentea,* listing the more important species, is presented in Table 3. In the table, abundance is indicated as "cover"—ground cover for herbs, canopy cover for shrubs and trees—as follows: + = < 5%; 1 = 6–20%; 2 = 21–40%; 3 = 41–60%; 4 = 61–80%; 5 = 81–100%. The total number of species in the stands ranges from 17 in stands 1 and 3, to 35 in stands 21, 28 and 30.

6. *Growth and Development*

(a) *Morphology:* The cotyledons of *S. argentea* are oval to elliptic, about 5 mm long. Seedling leaves are small, 10 to 15 mm long, elliptic, and show the same pubescence as mature leaves. Growth is very slow; seedlings

TABLE 2. Approximate locations of *Shepherdia argentea* stands in Table 3.

Stand No.	N latitude	W longitude	Stand No.	N latitude	W longitude
1	108° 18′	50° 15′	16	110° 35′	50° 02′
2	108° 17′	50° 41′	17	109° 47′	50° 56′
3	108° 40′	50° 57′	18	107° 57′	50° 40′
4	109° 34′	50° 05′	19	107° 15′	52° 43′
5	105° 04′	50° 05′	20	106° 49′	50° 10′
6	111° 17′	49° 08′	21	106° 52′	52° 47′
7	110° 05′	49° 56′	22	106° 50′	51° 51′
8	108° 28′	49° 20′	23	111° 50′	50° 44′
9	107° 30′	49° 07′	24	106° 30′	51° 03′
10	107° 35′	50° 13′	25	106° 40′	51° 52′
11	106° 55′	50° 55′	26	110° 30′	51° 33′
12	106° 30′	51° 03′	27	112° 52′	51° 27′
13	107° 05′	51° 16′	28	108° 20′	52° 42′
14	112° 10′	50° 52′	29	99° 15′	49° 40′
15	110° 42′	50° 52′	30	99° 25′	49° 37′

reached a height of about 10 cm, with three pairs of leaves, in 90 days (Figure 6). Two-year old stems can reach a height of 30 to 40 cm; five-year old stems average about 1.5 m.

(b) *Physiology:* The presence of several alkaloids in the roots and root-bark of *S. argentea* has been determined (Ayer and Browne 1970). Amongst these are $N_1$0-diacetyltetrahydroharmol (C16 H18 $M_2 0_3$), tetrahydroharmol (C12 H14 $M_2$0), and several non-polar bases. The presence of 5-hydroxytriptamine and its metabolites is discussed by Regula (1975). Although hydroxytriptamine (serotonin) is chemically related to adrenalin and some hallucinogenic drugs, and is known to cause constriction of blood vessels, and increases blood clotting, no medical properties, beneficial or otherwise, are ascribed to *S. argentea.* Some of these substances may impart the bitter taste to the foliage.

(c) *Phenology:* Flowering usually begins in late April or early May. The earliest flowering I have observed at Swift Current was on 4 April 1981, but this is exceptional. At Treesbank, Manitoba, the average first flowering is 4 May, the earliest 5 April (Criddle 1927). On the basis of long-term observations, Budd and Campbell (1959) calculated that flowering begins, on an average, seven days later at Swift Current than at Treesbank. Hence, the average date of first flowering at Swift Current would be 11 May. Leaves begin to expand about a week after flowering begins, and are fully expanded in late May or early June; leaves appear earlier on sterile stems than on fertile ones. Berries are formed in late May or early June, and ripen in late July or early to mid-August. Criddle (1927) gives a period of 107 days for the seed to ripen from first flowering. The ripe berries remain on the shrubs and, if not eaten, dry berries may still be present in the early spring of the next year. New leaf- and flower-buds are formed in late summer or early fall, before the leaves are shed.

7. *Reproduction*

(a) *Floral biology: Shepherdia argentea* is insect pollinated [see section 9(c)]. Male and female plants begin flowering at the same time, stamens ripen within two days after the flowers open. The flowers on a single branch or in a cluster usually open in sequence; thus, fertilized flowers, flowers in which the pollen has been shed, and unopened buds can be found on the same branch. Counts in several locations showed that male flowers average three flowers per cluster, female flowers average six per cluster, with the number of clusters for both sexes approximately equal.

(b) *Seed production and dispersal:* The fruit is an achene, enclosed in the enlarged calyx which forms the drupe-like, elliptic, orange-red to red, 5 to 6 mm long "berry". The achene is somewhat kidney-shaped, about 4 mm long by 2 mm wide, flat, shiny light brown to brown, very hard (Figure 3f). Collecting berries from plants on which flower counts had been made in spring showed that considerably less than half of the flowers had been fertilized. Even so, shrubs of 2 to 3 m height may produce in excess of 10 000 seeds. Dispersal of the seeds is probably mainly in the droppings of birds and ungulates. Pellets of Mule Deer, and droppings of Cedar Waxwing were examined; both contained achenes. A few berries usually remain on the shrubs throughout the winter and fall off in spring.

TABLE 3. List of the most important species in shrub communities with *Shepherdia argentea* (Pursh) Nutt.

Shrub cover, %	70	60	80	80	80	60	80	60	60	80	70	70
Tree cover, %	—	—	—	—	—	—	—	—	—	—	—	—
Herbaceous cover, %	20	20	20	20	20	20	30	30	30	40	40	40
Area of stand*	1	1	2	1	2	3	3	1	2	2	2	2
Stand number	1	2	3	4	5	6	7	8	9	10	11	12
Shepherdia argentea (Prush) Nutt.	4	3	4	4	4	3	4	3	3	4	3	3
Prunus virginiana L.	+	1	1	1	1	1	1	1	1	+	1	1
Rosa woodsii Lindl.	+	+	+	+	+	+	+	+	+	+	+	+
Amelanchier alnifolia Nutt.	+	1	+	+	+	1	+	1	1	1	1	+
Symphoricarpos occidentalis Hooker	+	+	+	+	+	+	+	+	+	+	+	+
Ribes oxyacanthoides L. s.l.	+	+	+	+	+	+	+	+	+	+	+	+
Rosa acicularis Lindl.	+	.	+	+	.	.	.	+	+	+	.	.
Cornus alba L.	.	.	.	+	+	+	+	+	+	+	+	+
Crataegus rotundifolia Moench	.	.	.	.	.	.	.	+	+	+	+	1
Viburnum edule (Michx.) Raf.	.	.	.	.	.	.	.	.	.	.	.	.
Populus tremuloides Michx.	.	.	.	.	.	.	.	.	.	.	.	.
Populus balsamifera L.	.	.	.	.	.	.	.	.	.	.	.	.
Betula occidentalis Hooker	.	.	.	.	.	.	.	.	.	.	.	.
Populus deltoides Marsh. s.l.	.	.	.	.	.	.	.	.	.	.	.	.
Viburnum lentago L.	.	.	.	.	.	.	.	.	.	.	.	.
Salix bebbiana Sarg.	.	.	.	.	.	.	.	.	.	.	.	.
Salix discolor Muhl.	.	.	.	.	.	.	.	.	.	.	.	.
Salix lutea Nutt.	.	.	.	.	.	.	.	.	.	.	.	.
Salix interior Rowlee	.	.	.	.	.	.	.	.	.	.	.	.
Smilacina stellata (L.) Desf.	+	+	+	+	+	+	+	+	+	+	+	+
Agropyron trachycaulum (Link) Malte	+	+	+	+	+	+	+	+	+	+	+	+
Galium boreale L.	+	+	+	+	+	+	+	+	+	+	+	+
Bromus ciliatus L.	+	+	+	+	+	+	+	+	+	+	+	+
Solidago canadensis L.	.	.	+	+	+	+	+	+	+	+	+	+
Anemone canadensis L.	.	+	+	.	.	+	+	.	+	+	+	+
Oryzopsis micrantha (Trin. & Rupr.) Thurb.	+	+	+	.	.	.	.	.	.	.	.	+
Achillea millefolium L. s.l.	.	.	.	.	.	.	.	.	.	.	+	+
Viola adunca Smith	.	.	.	.	.	.	.	.	.	.	.	+
Artemisia ludoviciana Nutt.	.	.	.	.	.	.	.	.	.	.	.	.
Arenaria lateriflora L.	.	.	.	.	.	.	.	.	.	.	+	.
Carex rossii Boott	.	.	.	.	.	.	.	.	.	.	.	.
Urtica dioica L. var. procera (Muhl.) Wedd.	.	.	.	.	.	.	.	.	.	.	+	+
Viola rugulosa Greene	.	.	.	.	.	.	.	.	.	.	.	.
Glycyrrhiza lepidota (Nutt.) Pursh	.	.	.	.	.	.	.	.	.	.	.	.
Juncus balticus Willd. s.l.	.	.	.	.	.	.	.	.	.	.	.	.
Carex praegracilus Boott	.	.	.	.	.	.	.	.	.	.	.	.
Carex sprengelii Dewey	.	.	.	.	.	.	.	.	.	.	.	.
Astragalus canadensis L.	.	.	.	.	.	.	.	.	.	.	.	.

*1 = 225 m^2; 2 = 450 m^2; 3 = 675 m^2.

TABLE 3. Continued

70	70	70	70	70	70	70	70	60	60	60	60	50	50	50	50	50	50
-		—	—	—	—	5	5	40	30	30	40	30	30	30	30	30	30
40	50	50	50	40	40	50	60	60	60	60	50	60	60	50	50	40	40
2	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2
1	1	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
+	1	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
+	+	+	+	+	.	+	+	+	+	+	+	+	+	+	+	+	+
+	+	+	+	+	+	+	+	+	.	+	+	.	+	+	+	+	+
1	.	+	+	+	+	.	+	+	.	.	+	+	+	+	+	+	+
.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+
.	.	.	.	.	.	+	+	1	.	1	.	.	+	+	+	+	+
.	.	.	.	.	.	.	.	1	1	1	1	.	.	.	.	.	+
.	.	.	.	.	.	+	+	2	1	1	+	+	+	+	+	+	+
.	.	.	.	.	.	.	.	.	.	.	2	2	2	2	2	2	2
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
.	.	1	1	1	1	1	1	+	+	+	+	+	+	+	+	+	+
.	.	.	.	.	.	.	.	+	+	+	+	+	+	+	.	+	+
.	.	.	.	.	.	.	.	+	.	+	+	+	.	+	+	+	+
.	.	.	.	.	.	.	.	+	+	+	+	.	+	+	.	.	.
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
+	+	+	.	+	+	.	+	+	+	+	+	+	+	+	+	+	+
+	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.
+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
+	+	+	+	+	+	+	+	.	+	+	.	+	+	+	+	.	+
.	+	.	+	.	+	.	+	+	+	+	+	+	+	+	+	+	+
+	+	.	+	.	+	+	.	+	.	+	+	+	.	+	+	+	+
+	+	.	.	+	.	.	.	+	+	+	.	+	+	.	.	.	.
.	+	.	.	.	.	+	+	+	.	.	+	+	+	+	.	+	+
.	.	+	+	.	+	.	+	.	+	+	.	+	.	+	+	+	+
.	.	.	.	.	.	.	.	+	+	+	+	+	+	+	+	+	+
.	.	.	.	.	.	.	.	+	+	+	+	+	+	+	+	+	+
.	.	.	.	.	.	.	.	.	+	.	+	+	+	.	.	.	.
.	.	.	.	.	.	.	.	+	.	+	.	.	.	+	+	+	+
.	.	.	.	.	.	.	.	+	+	+	.	+	.	.	.	.	.

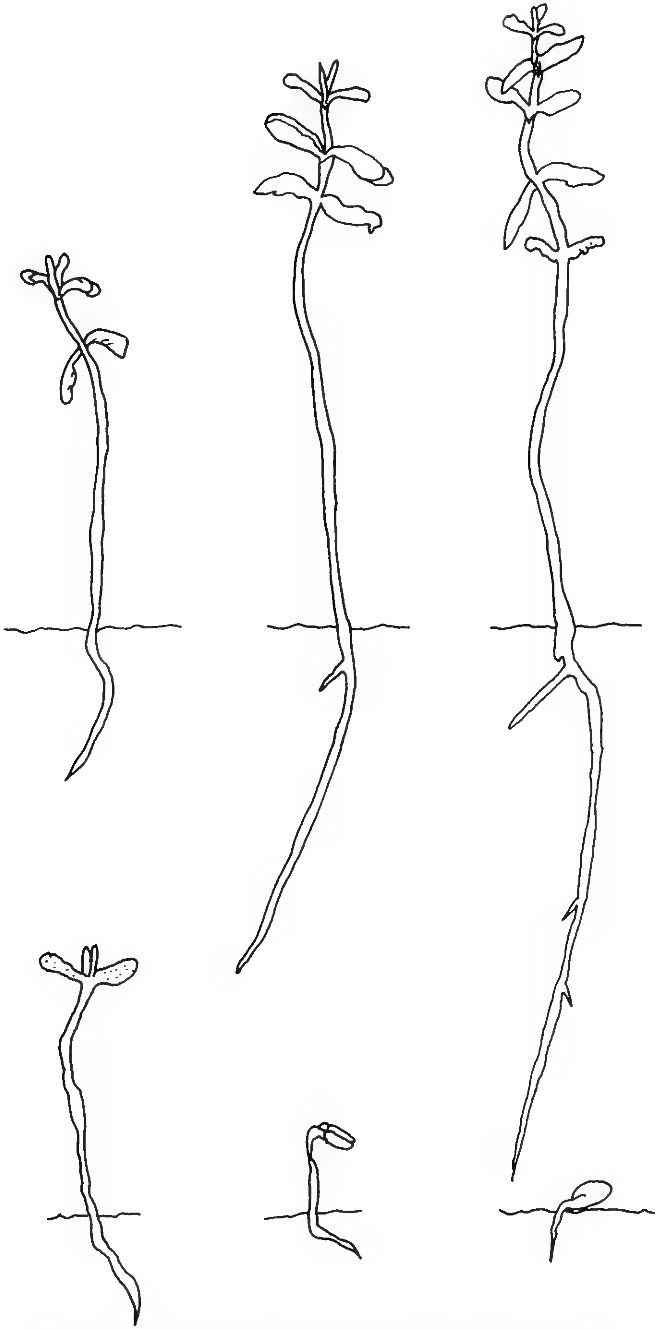

FIGURE 6. Seedlings of *Shepherdia argentea;* age, clockwise from lower right, 1, 3, 14, 28, 42 and 96 days. Scale about 1:1.

(c) *Seed viability and germination:* Fresh seed does not readily germinate; it is necessary to scarify the seed, followed by stratification for 30 to 50 days at 0 to 5°C. Scarification can be done by chemical or mechanical means; scarification in sulfuric acid, or removing part of the seed coat with a sharp file can give the same results. In fresh seed 80 to 90% germination can be obtained (G. B. Neill, P.F.R.A. Tree Nursery, Indian Head, personal communication, 1980).

In my own germination tests, the percentage germination in fresh seed, following the methods described, varied from 26% to 76%. In three-year old seed the viability appears to be reduced; maximum germination was only 30%, and more than half of the seedlings did not develop properly. Pre-treated seed germinates in 10 to 16 days; growth of the seedlings is very slow (Figure 6). The Plains Bison consumed the berries in late fall and early winter, and may have played an important role in dispersing viable and "scarified" seed when it was abundant on the Great Plains. No seedlings have been found in the natural habitat of the species, despite copious seed production.

(d) *Vegetative reproduction:* Virtually every clump of *S. argentea* is partially or entirely surrounded by a fringe of young shoots, arising from the often meters-long rootstocks. Usually, the age of the shoots decreases outward, with one- and two-year old shoots at some distance from the clump margin. However, where older shoots have died off for some reason, one- or two-year old shoots can be found amongst the older ones. The ages of several shoots determined from their growth rings, turned out to be considerably less than that of the root-crown from which they arose. Each of these root-crowns showed repeated damage through browsing by rabbits, followed by production of new shoots. The absence of seedlings, and uncertainties of true age determinations, made it impossible to estimate the age of seedlings at which the rootstocks are produced. It n, however, that one- and two-year old shoots can produce rootstocks. At present, at least, vegetative reproduction of the species far outweighs sexual reproduction in importance. This implies that the species does not now establish in new areas, and encroaches into adjacent areas only by lateral expansion of existing stands.

8. *Population Structure and dynamics*

(a) *Dispersion patterns:* The present distribution pattern of *S. argentea* is probably a result of vegetative reproduction, rather than that of seed dispersal. Most of the stands appear to be clones, rather than aggregates of several individual shrubs. Stands in which the sexes are mixed occur where male and female clones are close enough for rootstocks to reach neighbouring stands.

(b) *Age distribution:* All stands examined are composed of shrubs of varying age, but clustered around shrubs at least 25 to 30 years old, which form the centre of the stand. Along transects, laid out from the centre to the periphery, the age of shrubs diminishes, usually in age classes, i.e., the age distribution is not continuous, but

FIGURE 7. Dry-mesic stand of *Shepherdia argentea,* showing doime-shaped outline, northeast of Duchess, Alberta.

tends to be in groups of, e.g., 15–17, 8–10, 4–6 and 3 years old. Although the youngest shoots are always on the periphery of the stands, young shoots may usually be found amongst older shoots, not arising from old root crowns. The explanation for the age classes is probably that in some years all or most of the new shoots die, possibly because of injury by wildlife.

(c) *Size distribution:* Size of plants is usually directly related to age, and vigorously growing stands are dome-shaped (Figure 7). Shrubs reach their maximum height at about 17 to 20 years.

(d) *Growth and turnover rates:* Compared to the production of new shoots, turnover is relatively high in most stands. Grazing of young shoots, and girdling of stems in winter by rabbits, hares and deer results in a high death rate, and expansion of stands is slow. Thus, radial growth of eight stands in which transects were laid out, averaged 46 cm/yr over periods varying from 28 to 40 + years. Vegetative shoots grow slowly; measurements on many shoots show an average growth of about 13 cm/yr until about five years of age, about 18 cm/yr thereafter. Radial growth of the stems averaged 2.5 mm/yr.

(e) *Successional role:* Because no seedlings of *S. argentea* have been found in nature, the successional role of the species can only be assessed from its occurrence in old stands. The botanical composition of such stands (Table 3) indicates that the species may be able to establish as a pioneer in favourable habitats. Once established, it affords shelter for other shrubby species, and in time trees can enter into the shrub communities. It is likely that the nitrogen-fixing ability of *S. argentea* is important for other species and in the establishment and maintenance of shrub communities.

9. *Interaction with Other Species*

(a) *Competition:* Competition at the seedling stage could not be evaluated. However, the slow growth of seedlings in germination tests, and the apparent palatability of young shoots to rabbits, hares, and probably deer, as evidenced by the presence of large amounts of droppings, make it likely that the success rate of seedlings in nature would be small, except where these animals are rare. Nevertheless, though many of the young shoots die off at various ages or are greatly retarded in growth, in most old stands a steady advance into surrounding grassland can be seen. New shoots are commonly produced at 30 to 40 cm intervals, and occasionally as much as 90 cm advance.

(b) *Symbiosis:* The most common pollinators I observed on *Shepherdia argentea* were bees of Apidae and Megachilidae with *Bombus* spp. less common. A few small flies, possibly Lauxaniidae, were observed on both male and female flowers. A small flower beetle (Cetoniinae) was found on male flowers. *Shepherdia argentea* harbours a symbiont on its root system. The identity of this organism is still under investigation, but preliminary work indicates that it belongs to the coccid bacteria, rather than the actinomycetes, usually cited as the symbionts of other nitrogen-fixing shrubs (Akkermans 1978). Thus far, however, attempts to inoculate *Shepherdia* seedlings with the organism have been unsuccessful. The nodules formed by the organism range in size from greatly inflated roothairs, about 2 × 1 mm, to often grape-like clusters, 10 to 15 mm across, with lobes 2 to 3 mm in length and 1 mm in diameter. Nodules are most numerous on the fibrous roots at the base of shrubs and shoots, but occur more sparsely along the rootstocks between shoots (Figure 8). Nodules appear to be most active during the leaf expansion stage. According to Moore (1964), cross-inoculation between members of Elaeagnaceae is possible, even with the Old World member *Hippophaë*.

(c) *Predation and parasitism:* Despite the sharp thorns, both the berries and, to a small extent, the foliage of *S. argentea* are used by wildlife and livestock. The vernacular names "Buffaloberry" and "Bull berry" derive from the fondness of the Plains Bison (*Bison bison*) for the berries (Grinnell 1962). I have observed domestic cattle as well as Mule Deer (*Odocoileus hemionus*) eating the berries, and browsing on the foliage. Browsing of young shoots on which the thorns have not yet fully developed, by cattle and deer, as well as the Cottontail (*Sylvilagus nuttallii*) and Jack Rabbit (*Lepus townsendii*), is especially common. New shoots on root crowns with remains of shoots browsed in previous years are usually numerous. Cottontail, Jack Rabbit and deer also eat the bark of the stems in winter, sometimes girdling and killing many of the stems. The Cedar Waxwing (*Bombycilla cedrorum*) and Sharp-tailed Grouse (*Pediocetes phasianellus jamesii*) eat the berries in fall. Larvae of a June Beetle (*Phyllophaga* sp. subfamily Melolonthinae, family Scarabaeidae) and Click beetle (Elateridae) were found feeding on the roots.

(d) *Toxicity and allelopathy:* No reports of either phenomenon have been published.

FIGURE 8. Rootstock of *Shepherdia argentea* with nodules of symbiont; the root-crown is about 10 years old. Scale about 0.7x.

10. *Evolution and Migration*

No reports of studies on possible evolutionary development of *S. argentea* have been seen. However, studies by Arohonka and Rousi (1980) suggest that *Shepherdia* is genetically closer to *Hippophaë* than to *Elaeagnus.* Differences in taxonomic characters, as well as chromosome numbers and chromosome size indicate separate lines of evolution for all three genera. Migration of *S. argentea* in the present area of distribution is post-glacial, and may have been from the east as well as from the south. Pollen of the species have been found in late Pleistocene and Holocene deposits in the Great Lakes region (McAndrews et al. 1973). Although its occurrence in the deposits is indicated as rare, the Great Lakes region may have served as a minor emigration centre.

11. *Response Behaviour*

(a) *Fire:* Although fire can cause severe damage to old stands of *S. argentea,* especially when much dead wood is present, stems of 20 + years usually survive at least in part. The root systems are seldom severely damaged, and vigorous sprouting after a fire often results in increased density of the stand within a few years.

(b) *Grazing and harvesting:* Grazing of young sprouts by rabbits, as well as browsing by deer appear to be quite common judging by the amounts of droppings observed. Only first and second year shoots appear to be eaten; older shoots usually develop sharp thorns and become less attractive. Recovery of shoots, even when grazed several years in succession, has been noted in several stands. The shrubs are of no commercial value, and are not harvested.

(c) *Flooding:* In most of the areas where the species is common, spring flooding occurs more or less regularly. Plants do not show any adverse signs, even when surface water is still present after the foliage is fully expanded.

(d) *Drought:* Although *S. argentea* is most common in habitats where the soil water table is usually at a relatively shallow depth, in dry periods drought conditions can develop. Thus, in June 1980, the water table in several stands had dropped below 1.20 m, and signs of drought stress showed on some of the younger shoots on

the periphery of the stands. The taproots, which develop at irregular intervals along the rootstocks, penetrate to at least 80 cm depth, and may well reach into soil water even in times of drought.

(e) *Herbicides:* Attempts to eradicate *S. argentea* by means of herbicides are successful only when applied at uneconomically heavy rates. Spraying with 2,4-D Ester or 2,4,5-T on young growth at a rate of 2 to 3 kg/ha, and repeated in two following years can be successful, but benefits seldom warrant the expense. Applications of the herbicide Simazine at rates of about 3.5, 7.0 and 10 kg/ha enhanced the growth of *Shepherdia* seedlings by suppressing weeds, after 16 months the weight of seedlings at the three rates of Simazine applications had increased 1.8, 4.6 and 7.0 times, respectively. The height of the seedlings increased 1.2, 1.9 and 1.6 times, respectively. Hence, the rate of 10 kg/ha, although not affecting the weight, did affect the growth in height of the seedlings (Grover and Morgan 1972). The marked response of *S. argentea* to elimination of competition by other species in the establishment period may well indicate a relatively low competitive power, and may in part account for the fact that seedlings of the species in nature appear to be very rare.

(f) *Chemical changes:* No reports of response to toxic substances other than herbicides, or to fertilizers have been seen.

12. *Relationship to Man*

Various tribes of Plains Indians used the "bull berries" fresh or dried. The berries were a favorite fruit of the Blackfoot Indians (Grinnell 1962; Johnston 1970). At present, berries are used occasionally for making of jams, jellies and wine. Ranchers consider the shrubs a nuisance, but eradication is difficult and costly, while stands are rarely extensive enough to cause large losses in carrying capacity of pastures.

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Notes

Distribution of Small Mammals on Nine Small Coastal Islands in Southwestern Nova Scotia

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Thurber, Gary D., and Thomas B. Herman. 1984. Distribution of small mammals on nine small coastal islands in southwestern Nova Scotia. Canadian Field-Naturalist 98(2): 245–247.

Populations of small mammals on nine small (0.1–92 ha) inshore coastal islands near Barrington, Nova Scotia (43°32′N, 63°35′W) were sampled by snap-trapping in order to examine the distributions and habitat preferences of species present. *Microtus pennsylvanicus, Clethrionomys gapperi* and *Blarina brevicauda* were the most widely encountered species. *Peromyscus leucopus* and *Sorex cinereus* each occurred on two islands. *M. pennsylvanicus* and *C. gapperi* co-occurred on three islands, with no evidence of habitat segregation or competitive exclusion.

Key Words: island populations, small mammals, distribution, Meadow Vole, *Microtus pennsylvanicus,* Red-backed Vole, *Clethrionomys gapperi,* White-footed Mouse, *Peromyscus leucopus,* Short-tailed Shrew, *Blarina brevicauda,* Masked Shrew, *Sorex cinereus.*

Among small mammals, as in most taxa, fewer species occur on islands than on the adjacent mainland (Gliwicz 1980), and habitat preferences of individual species often diverge (Grant 1970a; Crowell and Pimm 1976). In addition, body size and longevity of small mammals on islands frequently exceed those on the mainland. In temperate coastal North America the Meadow Vole, *Microtus pennsylvanicus,* is probably the commonest rodent on small islands, while the Deer Mouse, *Peromyscus maniculatus,* and the White-footed Mouse, *P. leucopus,* generally only persist on larger islands. Although *M. pennsylvanicus* is a good colonizer of islands it suffers frequent extinctions (Crowell 1973). On the other hand, the Red-backed Vole, *Clethrionomys gapperi,* is a relatively poor colonizer, is constrained ecologically, and only occurs on the largest, least remote islands. The ability of a species to colonize is affected by its need for dispersal, its motility, its habitat requirements and the presence or absence of competitors and predators. The relative importance of these factors in determining species composition in island rodents has been recently discussed by Simberloff and Connor (1981).

In September and October 1980 and 1982 a total of nine small near-shore islands was sampled for small mammals (Figure 1). On the six smallest islands (Thrum Cap, 0.10 ha; Bald Thrum, 0.30 ha; Cove Thrum, 0.30 ha; Blackberry Island, 0.50 ha; One Tree Island, 0.50 ha; Pound Island, 1.0 ha) single transects were established along the longest axis of each island from shore to shore.

Two transects, a minimum of 100 m apart, were established on each of the three largest islands (Banks Island, 8 ha; Hogg Island, 14 ha; and Sherose Island, 92 ha).

In all transects, pairs of Museum Special[R] break-back traps were placed at 10 m intervals. Traps were baited with peanut butter and set for at least two consecutive nights in each location. All specimens were weighed, measured and necropsied; skulls are deposited in Acadia University Museum (MA 1868–MA 1975).

Of the nine islands, only one (Thrum Cap) lacked small mammals, although *M. pennsylvanicus* had been trapped there in 1979. On the remaining eight islands, three rodent and two insectivore species were encountered (Table 1). *M. pennsylvanicus* was the only rodent on three of the islands. All three had primarily open, grassy habitats with only limited wooded areas. *M. pennsylvanicus* and *C. gapperi* occurred on one small, entirely wooded, island. All three rodent species (*M. pennsylvanicus, C. gapperi, P. leucopus*) were captured on two of the larger predominantly wooded islands, in which limited grassy microhabitats were present. *C. gapperi* occurred alone on two mainly wooded islands, including Sherose Island, the largest island sampled. *P. leucopus* was not found alone on any island.

The three islands containing *M. pennsylvanicus* are likely only suited to this species because of their small size and open grassland vegetation. *C. gapperi* and *P.*

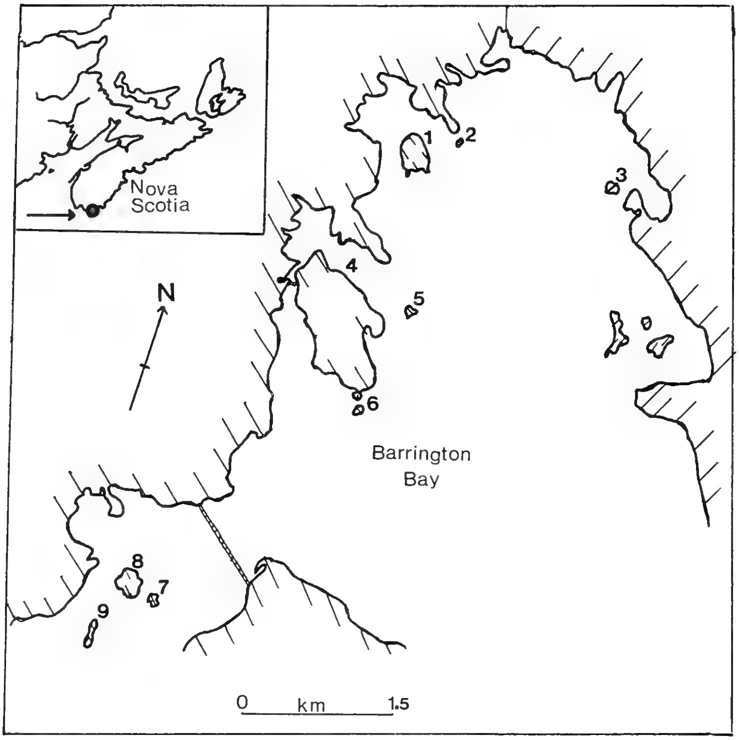

FIGURE 1. Study area. 1 — Hogg Is., 2 — Thrum Cap; 3 — Blackberry Is.; 4 — Sherose Is.; 5 — One Tree Is.; 6 — Bald Thrum; 7 — Cove Thrum; 8 — Banks Is.; 9 — Pound Is.

leucopus are both woodland species, and generally require larger islands (Crowell 1973).

The islands containing only *C. gapperi* were predominantly wooded, but contained some habitat suitable for *Microtus*. The apparent absence of the latter from these two islands may only reflect the extremely low numbers of *M. pennsylvanicus* on the adjacent mainland at the time.

On the island containing *C. gapperi* and *M. pennsylvanicus* only, competitive exclusion, suggested for these two species by Grant (1970b), had obviously not occurred. We are unaware of any previous reports of this species pair alone on a coastal island. Its presence may simply be due to chance (Simberloff and Connor 1981). Alternatively, coexistence may be facilitated by unfavorable climate, or by predation, both of which might dampen competition by preventing the buildup of high densities (Wiens 1977). In southwestern Nova Scotia winters are particularly harsh for small mammals because of extreme temperature fluctuations and lack of a persistent protective snow cover (Gates 1975).

On the two islands inhabited by all three rodent species, densities of all species were relatively low on one (Banks), but on the other (Hogg) densities of *C. gapperi* and *M. pennsylvanicus*, in particular, were relatively high. Not only did these three species coexist on Hogg Island, but there was little evidence of habitat segregation. Of ten multiple captures (nine double, one quadruple) at single trap points, *C. gapperi* and *M. pennsylvanicus* were captured together at three. In addition, the two species were caught at adjacent trap points more frequently than any other species combination (Thurber 1982). Oddly, more *C. gapperi* than *M. pennsylvanicus* were caught near the periphery of the island, despite the fact that this area was dominated by grassy vegetation.

It is interesting to note that among *M. pennsylvanicus* on islands containing both *M. pennsylvanicus* and *C. gapperi*, males were significantly larger (older?) than females, but on islands containing only *M. pennsylvanicus* size did not differ between the sexes.

Both the Masked Shrew, *Sorex cinereus* and the Short-tailed Shrew, *Blarina brevicauda* were captured

TABLE 1. Distribution and abundance of small mammals on inshore coastal islands in Barrington Bay.

Location	Year	Island size (ha)	Trapping effort (TN)	Vegetation Type	(≃% cover)	Number of Captures Rodentia *M.p.*	*C.g.*	*P.l.*	Insectivora *S.c.*	*B.b.*
Thrum Cap	1980	0.1	10	wooded (a) with grassy understory	100%	—	—	—	—	—
Bald Thrum	1980	0.3	22	herbaceous (b) shrubby (c) wooded (a)	≃40% ≃40% ≃20%	8	—	—	—	—
Cove Thrum	1982	0.3	24	wooded (a) herbaceous (b) shrubby	≃60% ≃20% ≃20%	2	—	—	—	—
Blackberry I.	1980	0.5	55	wooded (a) shrubby (c)	≃85% ≃15%	2	6	—	—	—
One Tree I.	1980	0.5	57	herbaceous (b) shrubby (d)	≃50% ≃50%	14	—	—	—	3
Pound I.	1982	1.0	107	wooded (a) herbaceous (b) shrubby (d)	≃60% ≃20% ≃20%	—	1	—	—	—
Banks I.	1982	8.0	385.5	wooded (a) shrubby (c) and herbaceous (b)	≃90% ≃15%	1	1	2	—	—
Hogg I.	1980	14.0	287	wooded (a) herbaceous (b)	≃85% ≃15%	21	30	8	1	1
Sherose I.	1980	92.0	192.5	wooded (a) herbaceous (b)	≃50% ≃50%	—	4	—	1	1

(a) primarily *Picea glauca*
(b) primarily *Graminae* spp.
(c) primarily *Rubus* L. spp.
(d) primarily *Rosa virginiana*

on the two largest islands. In addition, *B. brevicauda* was encountered on one of the smaller islands (One Tree). *Sorex cinereus* may have been overlooked on some islands, due to its low trappability in Museum Special[R] traps. This species is common on coastal islands elsewhere in Nova Scotia (Herman, unpublished data). Unfortunately the dynamics and distribution of shrew populations on islands has received little attention in the literature.

Of the nine islands sampled, colonization by and persistence of a particular species appear to be more related to island size, habitat and chance than to interspecific competition, particularly between *M. pennsylvanicus* and *C. gapperi.*

Acknowledgements

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Silver Hairgrass, *Aira caryophyllea*, New to Eastern Canada, and Other Notable Records from Seal Island, Nova Scotia

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Catling, P. M., V. R. Brownell, and B. Freedman. 1984. Silver Hairgrass, *Aira caryophyllea*, new to eastern Canada, and other notable records from Seal Island, Nova Scotia. Canadian Field-Naturalist 98(2): 248–249.

Important vascular plant records from Seal Island, Nova Scotia include *Aira caryophyllea, Nardus stricta* and *Crassula* [= *Tillaea*] *aquatica*. The first species has not previously been recorded in eastern Canada and the two latter species are both rare in Nova Scotia and in Canada. Nine other species new to the island flora are listed.

Key Words: Seal Island, Nova Scotia, eastern Canada, flora, new records, *Aira caryophyllea, Nardus stricta, Crassula* [= *Tillaea*] *aquatica*.

Erskine (1958) studied the flora of sixteen of the Tusket Islands (Yarmouth County, Nova Scotia) and enumerated 227 native and 71 introduced vascular plants. On the basis of an impoverished flora, dominance by certain species in small areas and an unexplained absence of certain species, he concluded that these drumlin islands had been colonized by plants accidentally and relatively recently. On Seal Island (*ca.* 43°25′N, 66°01′W) Erskine listed 133 native species and 50 introduced species. On 9-11 October 1982 we visited Seal Island and collected various plants, some of which represent important new records. These are listed below. Voucher specimens are deposited at ACAD, DAO and MICH.

Aira caryophyllea L.

Silver Hairgrass was previously known in Canada from Yukon and British Columbia (Boivin 1967; Scoggan 1978). In eastern North America it occurs in dry open places near the coast from Vermont and Massachusetts to Florida and Louisiana (Gleason and Cronquist 1963; Seymour 1969). All North American populations are considered to be derived from plants introduced from Europe (*loc. cit.).*

The discovery of this grass near Sand Cove on Seal Island represents the first record for eastern Canada. It occurred in relatively dry open sandy locations with a sparse cover of Beach Grass (*Ammophila breviligulata* Fern).

Seal Island is also the only location in eastern Canada for a closely related introduced species, Early Hairgrass (*Aira praecox* L.) (Erskine 1958; Roland and Smith 1969) which has a similar geographical distribution. It is common on the island in contrast to Silver Hairgrass which is rare. Both are annuals of dry open ground. Erskine (1958, p. 282) speculated that *Aira praecox* L. was "introduced to the island as seed in sand-ballast of ships driven up on the beach".

Nardus stricta L.

Introduced from Europe, Moor Matgrass is rare in Canada (Swales and Bider 1970). The only other Nova Scotia locality is Clyde River (Roland and Smith 1969). On Seal Island it is largely dominant over a few acres south of West Side.

This grass has a low nutritional value and a high fibre content (Swales and Bider 1970). Consequently it is avoided by grazing animals and dominates some areas of Europe where sheep have had a pronounced effect on the flora. Sheep have inhabited Seal Island for over 50 years and while there is much evidence of grazing in the early autumn, the Moor Matgrass remains untouched.

Crassula [= *Tillaea*] *aquatica* (L.) Schonl in Engler and Prantl

Pigmyweed is rare in Nova Scotia (Maher et al. 1978) and across Canada (Cody 1954). Its occurrence in an ephemeral seashore pool at Owens Point represents the first record for the Tusket Islands (Erskine 1958) and the first record for Yarmouth County (Roland and Smith 1969).

A number of other plants that were collected are new to the island on the basis of Erskine's (1958) list. Included are Rhode Island Bent (*Agrostis tenuis* Sibth.), Bluejoint (*Calamagrostis canadensis* (Michx.) Beauv.), Wart-cress (*Coronopus didymus* (L.) Smith), Spike-rush (*Eleocharis parvula* (R. & S.) Link), Mild Water-pepper (*Polygonum hydropiperoides* Michx.), Goosegrass (*Puccinellia pumila* (Vasey) Hitchc.), Pussy-willow (*Salix discolor* Muhl.), Heather Grass (*Sieglingia decumbens* (L.) Bernh.) and Cord Grass (*Spartina alterniflora* Loisel.).

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The Morphology of a Vegetatively Proliferating Inflorescence of Kentucky Bluegrass, *Poa pratensis*

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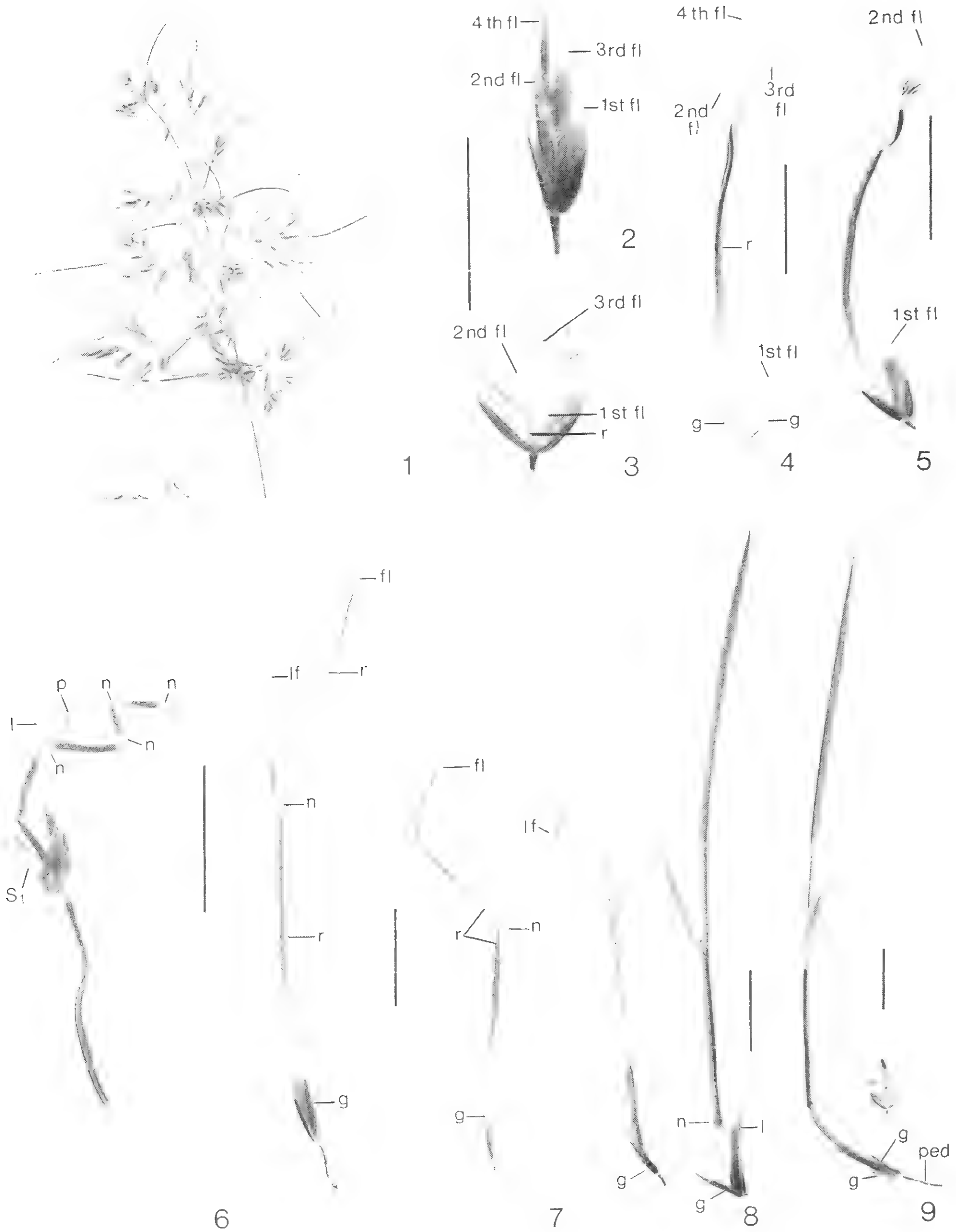
Aiken, S. G., and S. J. Darbyshire. 1984. The morphology of a vegetatively proliferating inflorescence of Kentucky Bluegrass, *Poa pratensis*. Canadian Field-Naturalist 98(2): 249–251.

A greenhouse-grown plant of Kentucky Bluegrass developed vegetatively proliferating spikelets that were more expanded than is usual in the field. Photographs were taken to illustrate a range of modifications that may occur during vegetative proliferation.

Key Words: Kentucky Bluegrass, *Poa pratensis*, vegetative proliferation, inflorescenes.

In Canada, vegetative proliferation in grasses is a common phenomenon, especially during years of abnormal climatic conditions. In the field the structures formed are usually compact and it is difficult to interpret the morphology. The *Poa pratensis* L. plant in the accompanying plate was grown in a greenhouse at the Central Experimental Farm, Ottawa, during May and June 1982. Probably because of the warm, humid growing conditions the propagating spikelets formed were abundant and much more expanded than is usually found in plants growing outside. Photographs of the inflorescence and the individual spikelets were taken to illustrate and interpret the range of morphological modifications that occurred.

Vegetative proliferation in grasses refers to the conversion of the spikelet above the glumes into a leafy shoot (Beetle 1980). It has been called ephemeral proliferation (Wycherley 1953) and is probably the phenomenon described as "spontaneous vivipary" (Frederiksen 1981). The shoots formed are not usually an effective method of reproduction in the wild, but they may be persuaded to grow under controlled conditions. Vegetative proliferation is ephemeral and may result from: (1) genetic aberrations, sometimes the result of hybridization or polyploidy; (2) injury, either mechanical or biological as from insects, nematodes or fungi; and (3) adverse environmental conditions such as excess water about the roots, high humidity, or insufficient vernalization. It is common in grasses grown in greenhouses. Wycherley (1953) suggested that any of the above conditions may lead to a hormonal imbalance with insufficient hormone being produced for normal flowering. Usually relatively few spikelets form leafy shoots of varying sizes, resulting in an odd, asymmetrical appearance to an inflorescence.



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Vivipary, in contrast with vegetative proliferation, refers to the development of deciduous vegetative propagules or bulbils in the spikelets. It is a genetically controlled, reproductive strategy of a relatively few grass species. In *Festuca vivipara* (L.) Sm., the fresh weight of the bulbils is at least 10 times that of the seeds of the closely related and non-viviparous *F. ovina* L. *sensu lato* (Frederiksen 1981). The bulbils normally develop adventitious roots before they are shed and in favorable conditions new plants develop rapidly. Only rarely does the lowest floret of the spikelet develop functional sexual organs. Almost every spikelet on the inflorescence will form bulbils of more or less similar morphology, resulting in a relatively uniform leafy appearance.

Vivipary is also used to refer to the germination of an embryo *in situ* before the seed falls, and without any dormancy period (Pope 1949). It has been observed in tropical bamboos, but has not been reported for any Canadian grass.

Beetle (1980), in a paper on vivipary, proliferation and phyllody (the metamorphosis of spikelet bracts, glumes, lemmas or paleas into leaves), presented an annotated list of more than 90 taxa of grasses where inflorescence variants have been recorded. Most of the taxa listed have spikelets with indeterminate growth. The list includes several species of *Poa* and seven references to *Poa pratensis*. All the references are European and none contain a diagram or photographs of the condition referred to.

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FIGURE 1. An inflorescence of Kentucky Bluegrass showing many spikelets undergoing vegetative proliferation. Actual size.

FIGURE 2. Young spikelet with four florets.

FIGURE 3. Spikelet with three florets at anthesis.

FIGURE 4. Spikelet with extensively elongated rachilla. At the base are the two glumes and a floret at anthesis. Between the first and second floret (also at anthesis) the rachilla internode has greatly elongated. Beyond the second floret is a third floret in bud and a fourth vestigial floret.

FIGURE 5. Similar to 4. The rachilla has elongated between the first and second florets. To the left of the second floret the rachilla is extended in a confused structure that has three scales which may represent reduced lemmas of vestigial florets.

FIGURE 6. A branch of the inflorescence bearing two spikelets. Spikelet S_1, to the left, has undergone only slight vegetative proliferation. In the other spikelet the rachilla has greatly elongated and vestigial florets, consisting of a leafy lemma and palea, have formed at the nodes.

FIGURE 7. In both spikelets the elongated rachilla has given rise to a vegetative leaf at the first node above the glumes and an apparently terminal floret at the second node.

FIGURE 8. Two vegetatively proliferating spikelets with glumes and one lemma at the base. The rachilla of the spikelets has undergone phyllody and formed a culm with developing leaves. A node is visible at the base of the culm in the right hand proliferating spikelet.

FIGURE 9. Right, normal spikelet; left, spikelet that has undergone almost complete vegetative proliferation. The floral origin is apparent by the pedicel of the spikelet and the two glumes.

Abbreviations, fl = floret, g = glume(s), l = lemma, lf = leaf, n = node, p = palea, ped = pedicel, r = rachilla, s = spikelet. Scale bar = 10 mm.

Photographs by C. E. Beddoe. Voucher specimen at Department of Agriculture herbarium, Ottawa.

Observations of Golden Eagle, *Aquila chrysaetos*, Predation on Dall Sheep, *Ovis dalli dalli*, Lambs

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Nette, Tony, Doug Burles, and Manfred Hoefs. 1984. Observations of Golden Eagle, *Aquila chrysaetos*, predation on Dall Sheep, *Ovis dalli dalli*, lambs. Canadian Field-Naturalist 98(2): 252–254.

Three observations of successful predation of Golden Eagles on Dall lambs from the southwestern Yukon are described. The frequency of observations of Golden Eagles hunting sheep during spring of 1982 may have been a reflection of the scarcity of other prey. The late birth of one of the lambs killed and the weight of prey a Golden Eagle may get airborne with were noteworthy.

Key Words: Dall Sheep, *Ovis dalli dalli*, Golden Eagle, *Aquila chrysaetos*, predation, predator-prey relationship, Yukon Territory.

Opinions on the role of the Golden Eagle in predation of wild sheep differ widely. This relationship has not been studied in detail, and the fact that these raptors are also scavengers complicates interpretation of field observations. While a number of investigators have witnessed Golden Eagle circle low over bands of sheep and even dive down and harass them (Banfield 1953; Berwick 1968; Hoefs 1975; Murie 1944; and Sheldon 1930), the actual killing of a lamb has only been reported once (Kennedy 1948). Dixon (1938), Murie (1944) and Sheldon (1930) considered Dall Sheep as completely indifferent to eagles. Palmer (1941) stated "The sheep appear unconcerned about the eagles' presence". On the other hand, F. Jones (1963; Sheep investigations. Alaska Department of Fish and Game. Project No. W-6-R-4) observed: "Many times bands of ewes and lambs can be located by the presence of a circling eagle", and Banfield (1953) reported: ". . . observations upon eagle-white sheep (*Ovis dalli*) relationships . . . led me to conclude that these raptors take a number of young lambs".

In contrast to the lack of information on eagle-wild sheep interactions several investigations have confirmed predation by these raptors on domestic sheep (O'Gara 1982; Tigner and Larson 1982). Golden Eagles in Europe also are reported to prey on the young of Chamois, *Rupicapra rupicapra* (Knaus 1960; Furschlberger und Nerl 1969), Roe Deer, *Capreolus capreolus* (Raesfeld 1965), and Alpine Ibex *Capra ibex* (Nievergelt 1966). Even larger ungulates occasionally fall victim to eagles. Cooper (1969) observed the killing of a Red Deer, *Cervus elaphus*, fawn; and Roseneau and Curatolo (1976) considered eagles important predators on the calving grounds of the Porcupine caribou, *Rangifer tarandus*, herd in northern Yukon and Alaska.

During investigations of Dall Sheep in Kluane National Park (Hoefs 1975; Hoefs and Bayer 1983) we have observed on two occasions that eagles had attacked and wounded sheep, and there have been many records of harassment. Actual killing was not documented, but mortality of lambs during the first few weeks of life was between 15 and 25%, which led us to assume that eagle predation must occur. At that time the ewes and young lambs are found in very difficult terrain, into which predators like Timber Wolf, Coyote, Lynx, Wolverine and Red Fox do not normally venture.

Observations

During sheep surveys in summer 1982 by staff of Yukon Wildlife Branch and Kluane National Park, a number of Golden Eagle-Dall Sheep interactions was recorded, of which three deserve documentation, since they establish for the first time successful eagle predation on Dall Sheep.

The following are excerpts from the relevant field notes:

1. 23 June 1982: helicopter survey in the Rose Lake area, southern Yukon, 60°20′N, 135°50′W, event witnessed by Tony Nette, Phil Merchant and pilot Dave Wood. ". . . a nursery band of sheep, totalling 25, was approached at the top of the bluffs at 1700 m above the lake. The approach was made from below to force the sheep up on the plateau, where a classified count could be easier accomplished. When the aircraft was about 800 m away, the sheep started to run and an eagle was observed to take flight about 50 m up hill from the sheep. The eagle maintained its height and distance from the sheep as we approached. One lamb was running about 2 to 3 m behind the band, until it

stumbled. By the time it regained its footing, it had fallen 7 to 8 m behind. As soon as the lamb fell the eagle began to close in, even though at this time the helicopter was only about 100 m away from the sheep. The eagle then hit the lamb and sent it sprawling. When it was back on its feet the eagle attacked again and this time it hung on to the lamb. They both rolled over once. The last scene, before the helicopter moved out of sight, was the eagle on top of the lamb bracing itself with its wings on the ground on either side. The hind leg of the lamb was still kicking."

2. 30 June 1982: observations made from the ground at Sheep Mountain Information Stand, Kluane National Park. "M. Flumerfelt and J. Sias observed a ewe high in the cliffs of Sheep Mountain (+1800 m) at 1:45 p.m. She moved about in a small area and continued to return to nuzzle a very small lamb. Dark coloration was noticed around the rear end of the ewe and on the lamb, suggesting recent birth. At 2:00 p.m. Warden D. Burles joined the watch. The ewe continued to lick and to nuzzle the lamb and on two occasions she tried to lift the lamb onto its legs but each time the lamb collapsed again. The behaviour of the ewe and lamb supported the assumption that the lamb was new born. Facial features and horn length suggested that the ewe was a young animal.

   At 2:06 p.m. a mature Golden Eagle landed in the rocks about 2 to 3 m above them. The ewe immediately took a protective stance with forelegs over the lamb and bowed her head as if to make a charge. The eagle watched for perhaps 30 sec and then suddenly dropped down in front of the ewe with wings spread. The ewe backed up slightly and as she did the eagle was able to drag the lamb out from under her. The eagle seized the lamb with its talons and dragged it downhill with wings flapping until it was able to get airborne. It immediately flew out of view and could not be located again. The ewe repeatedly laid down, stood up again and walked around as if searching. Observations discontinued at 3:10 p.m. when the ewe had bedded down again.

   Previously, there has been some doubt as to whether a Golden Eagle could carry off a lamb. This observation confirms that it is possible. The lamb was newly born and therefore could not have weighed very much. The lamb was also born abnormally late in the year and may have been smaller than an average lamb. There was a strong wind blowing (7 to 15 mph), which would have given the eagle added lifting power."

3. 06 July 1982: helicopter survey in the Ruby Range, east of Kluane Lake (61°23′N, 138°50′W), event witnessed by Tony Nette, Grant Lortie, Tom Bunch, and pilot Ron Eland. "During the survey we observed a very large nursery band near the top of the ridge next to Kluane Lake. At the same time we observed a Golden Eagle circling low above them. When we approached the sheep, which by then were dispersed into smaller bands in the cliffs, we could still see the eagle flying above them. When we had approached to about 400 m at an altitude of 1700 m the eagle suddenly closed in, seized a lamb and flew off with it into the valley below. At the time of attack the lamb was about 2 m behind its ewe and was closely followed by another ewe."

Discussion

We interpret the observations and particularly the observed frequency of eagle-sheep interactions in 1982 as follows:

Golden Eagles prey on Dall lambs when the opportunity presents itself but usually other prey are more important. During the winter of 1981/82 Snowshoe Hares and Willow Ptarmigan populations in the southwestern Yukon declined drastically, reaching by spring a very low level in their cyclical abundance. Groundsquirrels and smaller mammals were also scarce in 1982. The paucity of these more usual food items forced the eagles to attack alternate prey, of which Dall Sheep were the only abundant one. We have also observed that wolves and coyotes preyed more heavily on Dall Sheep than in previous years (Hoefs, Hoefs and Burles *in press*).

These observations, plus others conveyed to us by pilots, testify to an eagle's ability to successfully prey on Dall lambs. Concerns have been expressed that disturbance of the sheep bands by the helicopter may have predisposed these lambs to eagle attack. This possibility can not be ruled out, but sheep surveys using this methodology have been conducted by Yukon wildlife managers for the past 8 years, involving about 70 flying hours per year, and no eagle predation was observed except in 1982. Two other aspects of these observations warrant a brief discussion: The late birth day of the lamb in observation No. 2, and the ability of an eagle to get airborne with a lamb.

During intensive studies in 1969-1973 recorded birth dates of 180 lambs were from 30 April to 2 June, with most lambs born during the third week of May (Hoefs 1975). The lamb in observation No. 2 was born 42 days later than the mean birth date and 28 days later than the latest previously recorded birth here. In Alaska Dall Sheep lambing has been reported as late as 15 June (Palmer 1941). The late birth in observation No. 2 may support the assumption that the ewe was a young animal. In Europe, Mouflon Sheep

young ewes entering the rut for the first time often do so at a later date than older ewes from the same population (Hoefs 1982).

The weight of Dall lambs at birth varies from 3.2 to 4.1 kg (Nichols 1978). So the eagle's ability to take off with the new-born lamb (No. 2), particularly if it was a small one, is not surprising. The lamb on 6 July 1982 (No. 3) appeared to be between 40 and 50 days old. Lambs raised for experimental purposes at the Yukon Game Farm at the age of 40 to 50 days had reached mean weights of 12.5 kg to 14.7 kg (n = 6) (Hoefs, unpublished data). These captive sheep were about 10 to 20% heavier than wild animals of the same age. Therefore the eagle in observation No. 3 got airborne with a lamb of 10 to 12 kg. Of importance is the fact that the eagle did not have to ascend.

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A Recent Specimen of the Eastern Spiny Softshell, *Trionyx spiniferus spiniferus*, from Hamilton Harbour, Lake Ontario

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Obbard, Martyn E., and Norman E. Down. 1984. A recent specimen of the Eastern Spiny Softshell, *Trionyx spiniferus spiniferus*, from Hamilton Harbour, Lake Ontario. Canadian Field-Naturalist 98(2): 254–255.

The continued existence of the turtle *Trionyx spiniferus spiniferus* in the western end of Lake Ontario is confirmed by an adult male specimen.

Key Words: distribution, Eastern Spiny Softshell, Ontario, *Trionyx spiniferus spiniferus*.

The Eastern Spiny Softshell, *Trionyx spiniferus spiniferus*, was once considered a common turtle in the western end of Lake Ontario (Mills 1948). However, records of its occurence have decreased in recent years to the point that it was suggested that *Trionyx* might be extirpated from Lake Ontario (Campbell,

C. A. 1977. Range, requirements and status of the Eastern Spiny Softshell (*Trionyx spiniferus spiniferus*) in Canada. Unpublished ms. Canadian Wildlife Service, Ottawa).

The most recent records for Lake Ontario are from Lynde Shores Conservation Area near Whitby in 1970, and from Jordan Harbour on the north shore of the Niagara peninsula in 1971 (Campbell, C. A. 1980. A status report for the Eastern Spiny Softshell, *Trionyx spiniferus spiniferus*, in Canada. Unpublished ms. Ontario Ministry of Natural Resources, Toronto). Local naturalists consider *Trionyx* to be absent from Hamilton Harbour and Dundas Marsh (Campbell 1977). The last record of *Trionyx* in the Hamilton Harbour vicinity (Cootes Paradise, Royal Botanical Gardens) was some time between 1965 and 1967 (Campbell 1980, unpublished ms). Thus, the recent capture of an Eastern Spiny Softshell on the north shore of Hamilton Harbour is of particular significance.

On 4 September 1981 an adult male *Trionyx s. spiniferus* was captured by one of us (NED), in a trap net set for fish. The trap was set in 1.2 m of water over a soft, sandy bottom that supported a dense growth of aquatic vegetation. Water temperature when the specimen was captured was 20°C. The sex of the specimen was determined by the long, thick tail with cloacal opening near the tip (Ernst and Barbour 1972). The specimen had a carapace length of 20.4 cm and a plastron length of 14.6 cm. Adult male *Trionyx spiniferus* have carapace lengths of 12.7–21.6 cm (Ernst and Barbour 1972). Based on Breckenridge's (1955) estimate of growth in male *Trionyx spiniferus* in Minnesota, this Lake Ontario specimen was at least 15 and probably greater than 20 years old. This individual is being maintained alive in captivity as part of the herpetological teaching collection of the Department of Zoology, University of Guelph.

Incidental catches of other species of turtles in trap nets set for fish in Cootes Paradise and Hamilton Harbour were common in the period 1978-81, although exact numbers are unavailable. The most frequently captured were Common Snapping Turtles, *Chelydra serpentina*. Midland Painted Turtles, *Chrysemys picta marginata*, and Map Turtles, *Graptemys geographica*, were less common (Down unpublished).

Industrial and domestic pollution have caused severe degradation of water quality in Hamilton Harbour (Ontario Ministry of the Environment. 1978. Hamilton Harbour study, 1976. Unpublished ms. O.M.E., Toronto). Yet, encouragingly, several turtle species still appear to be abundant and this single record of a softshell raises the possibility that this species continues to survive in an area where it was thought to be extirpated.

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Pinesap, *Monotropa hypopithys,* New to the Flora of Manitoba

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Cody, William J., and Jacques Saquet. 1984. Pinesap, *Monotropa hypopithys,* new to the flora of Manitoba. Canadian Field-Naturalist 98(2): 256–257.

Monotropa hypopithys (Pinesap) is reported for the first time as occurring in Manitoba at Riding Mountain National Park. The known Canadian distribution is given. The segregation of the species into varieties in North America is not clear.

Key Words: *Monotropa hypopithys,* Pinesap, Manitoba.

Monotropa hypopithys (Pinesap) is a saprophytic plant of the subfamily Monotropoideae of the family Pyrolaceae. It is a circumpolar species which in Canada is found in moist coniferous woodlands or very rarely in areas that have been cut over. *Monotropa hypopithys* is not a common plant anywhere in Canada. Rarely are more than a few plants found at any given locality in any year. It is not a striking plant like *M. uniflora* (Indian Pipe), neither is it as common as that species. Scoggan (1979) gave the northern North American distribution of this plant from the Alaska Panhandle to Newfoundland, but specifically noted that it was not known from Manitoba. It was thus of considerable interest when a specimen of *M. hypopithys* was found during the examination of specimens in the preparation of a treatment of the plants of Riding Mountain National Park. Data for this collection are: MANITOBA: Riding Mountain National

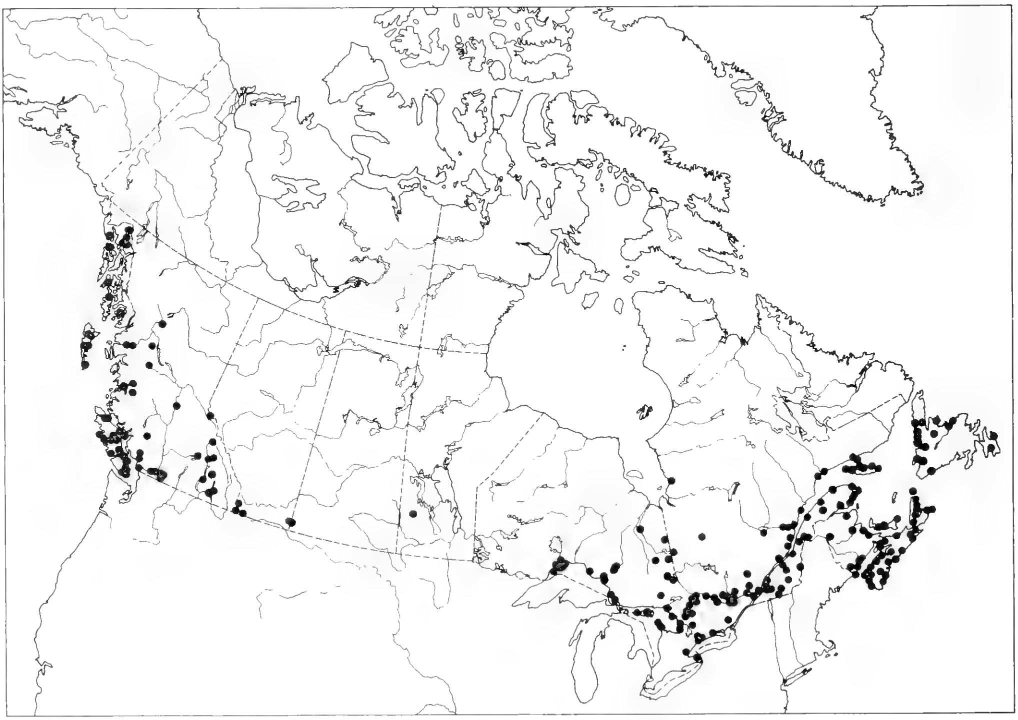

FIGURE 1. Map of the known Canadian distribution of Pinesap, *Monotropa hypopithys.*

Park, off Baldy Road and Central Trail junction at RM 027, *A. Schewe & D. Weedon,* 13 July 1978. (Herbarium of Riding Mountain National Park, photo DAO).

This collection is in the middle of a previously large gap in the known Canadian distribution of *M. hypopithys*. The nearest known stations to the west are in the Cypress Hills of southern Saskatchewan and Alberta (ca 725 km) and to the east on the northwestern shores of Lake Superior (ca 850 km). To the south in the United States McGregor et al. (1977) reported *M. hypopithys* from Cherokee and Douglas counties in Kansas, Jasper County in Missouri and Box Butte and Richardson counties in Nebraska, the closest of these being Box Butte (650 km).

Lakela (1965) reported that *Monotropa hypopithys* was rare in white cedar forests in northeastern Minnesota, and Deam (1940) stated that it was infrequent to rare, possibly in all parts of the state of Indiana, but pointed out that it was usually found in black and white oak woods and also in low flat beech and sweet gum woods.

A map of the known Canadian distribution of *Monotropa hypopithys* is given in Figure 1. This is based upon specimens preserved in the herbaria of the Biosystematics Research Institute, Agriculture Canada (DAO) and National Museum of Natural Sciences (CAN), both at Ottawa, University of Toronto (TRT) and Memorial University of Newfoundland (NFLD), supplemented by published records of Rousseau (1974) for Quebec, Roland and Smith (1969) for Nova Scotia, Prince Edward Island and New Brunswick, Hultén (1968) for Alaska, and Szczawinski (1962) for British Columbia. A map of the known worldwide distribution is given by Hultén (1968).

In view of its occurrence as far north as James Bay in Western Quebec, one would expect that *M. hypopithys* might occur in suitable habitats north and west of the head of Lake Superior, and in the boreal forests of northern Manitoba, Saskatchewan and Alberta, and it should be looked for there.

The species *Monotropa hypopithys* has been subdivided by some authors into an Old World var. *hypopithys,* an eastern North American ssp. *lanuginosa* (Michx.) Breitung, and a western North American var. *latisquama* (Rydb.) Kearney & Peables (*Hypopitys latisquama* Rydb.). As stated by Fernald (1950), this is "A complex species, needing careful study; the variations of pubescence of parts and of color not clearly supporting the differentiation of species as sometimes maintained." No attempt was made in this study to differentiate subspecific taxa.

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Organochlorine Pesticide and PCB Residues in Eggs and Nestlings of Tree Swallows, *Tachycineta bicolor*, in Central Alberta

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Shaw, George G. 1983. Organochlorine pesticide and PCB residues in eggs and nestlings of Tree Swallows, *Tachycineta bicolor*, in central Alberta. Canadian Field-Naturalist 98(2): 258–260.

Organochlorine pesticide and PCB residues in eggs and large nestlings were determined for Tree Swallows (*Tachycineta bicolor*) at five locations in central Alberta. Concentrations of dieldrin, pp'-DDD, pp'-DDT, alpha-chlordane, oxychlordane, beta-BHC and HCB were all less than 0.03 ppm. Concentrations of DDE, heptachlor epoxide and PCBs were about 1, 0.1 and 0.5 ppm, respectively, in eggs, and 0.3, 0.02 and 0.1 ppm in nestlings. Total body burdens of DDE and PCBs in nestlings were significantly higher than those in eggs at two of the locations, which suggests that adult Tree Swallows still receive some of their organochlorine pesticide and PCB burdens in Canada.

La concentration de résidus de pesticides organochlorés et de BPC a été déterminée dans les oeufs et les oisillons d'hirondelles bicolores (*Tachycineta bicolor*) provenant de cinq sites du centre de l'Alberta. Les concentrations de dieldrin, pp'-DDD, pp'-DDT, alpha-chlordane, oxychlordane, beta-BHC, ainsi que de HCB, se sont avérées inférieures à 0.03 ppm. Les concentrations de DDE, heptachlor epoxide, et de BPC, étaient d'environ 1, 0.1, 0.5 ppm respectivement dans les oeufs et de 0.3, 0.02, et de 0.1 ppm dans les oisillons. À deux endroits, l'accumulation de DDE et de BPC dans les oisillons était significativement supérieure à celle des oeufs, ce qui laisse donc croire que les hirondelles bicolores adultes peuvent encore accumuler au Canada une certaine quantité de pesticides organochlorés et de BPC.

Key Words: Tree Swallow, *Tachycineta bicolor*, organochlorine, PCB concentrations, burdens, eggs, nestlings.

Organochlorine pesticides (such as DDT and dieldrin, but excepting lindane) had not been used in the Canadian prairies for several years prior to 1978. This suggested that migratory birds like the Tree Swallow, *Tachycineta bicolor*, which breed in our agricultural areas would be feeding uncontaminated insects to their nestlings. On the other hand, some of those pesticides degrade very slowly under the anaerobic conditions in prairie wetland sediments. Much of that sediment is soil eroded from adjacent agricultural fields during the past. Therefore, many of the dipterous insects consumed by Tree Swallows may be contaminated with residues of organochlorine pesticides because their larval development occurs in the waters and sediments of prairie sloughs. In such cases, nestling Tree Swallows fed a diet of contaminated insects could contain total body burdens of organochlorine residue more elevated than the residues in eggs.

To test these suppositions eggs and well-grown nestlings of Tree Swallows were collected in 1978 and 1979 to determine residues of several organochlorine pesticides and PCBs in their tissues. Sampling was done by operators of bluebird nest-box trails where the majority of boxes were occupied by Tree Swallows. Independently, the anaerobic sediments of 112 sloughs were sampled to determine residue concentrations of the same chemicals.

Methods

The five bluebird nest-box trails, each with 50-60 nest boxes, were 12 km east of Fort Saskatchewan, along the eastern perimeter of Elk Island Park (Chipman), within 12 km east and west of Tofield, within two km east of the Gulf Oil refinery in Edmonton, and within 12 km south and west of Leduc. One viable egg was taken from each of several nest boxes widely separated along each trail when half the eggs of each clutch had been laid, thus ensuring minimal development. Subsequent to hatching, several unhatched eggs were collected at each trail from only those boxes having live nestlings. Later, several nestlings were taken from each trail four or five days before their flight feathers were sufficiently grown to permit flight.

In the laboratory eggs were weighed and their contents emptied into acetone-cleaned glass vials to make up composite samples representing each trail and egg condition. Composite samples for each trail were made also of nestlings without beaks and toenails.

Sediment samples from 54, 23 and 35 permanent sloughs in the Bittern Lake, Dusty Lake and Mundare areas were collected in 1978 for organochlorine pesticide and herbicide residue analyses. These areas were 25 km east or south of one or more of the bluebird trails. Several subsamples of sediment were combined according to crops and agricultural practices on adjacent land in each of the three areas.

All tissues and sediments were frozen and sent to the Ontario Research Foundation (ORF) for pesticide residue, percent crude fat (eggs and birds only) and moisture analysis. At the ORF avian tissue samples

were weighed, dried in a vacuum oven at 45° C, weighed again, ground with Na_2SO_4 and Soxhlet-extracted with 25 % ether in hexane. The solvent was removed by a rotary evaporator and weighed. The residue was taken up in hexane and cleaned up on a 2 % water-deactivated Florisil column for quantification of DDE, pp'-DDD, pp'-DDT, dieldrin, heptachlor epoxide, alpha chlordane, oxychlordane, beta BHC, HCB, and the PCB Aroclors 1254 and 1260, by electron capture-gas liquid chromatography (Reynolds and Cooper 1975). A 1:1 ratio of the two Aroclors was assumed in sample and reference material when measuring PCBs.

Sediment samples were doubly extracted with a 1:5 mixture of one normal sulphuric acid and diethyl ether. The pooled ether extracts were doubly-extracted with dilute alkali. Then the alkaline ether portion was analyzed for the above organochlorine pesticide and PCB residues by the same methods.

Means and variances, for viable and unhatched eggs and nestlings, of fresh weights, percent crude fat and moisture, ppm of DDE, heptachlor epoxide and PCBs were computed. Bartlett's homogeneity of variance test was applied as required before testing the significance of differences between means with Student's t ($p \leqslant .05$). Transformation of raw data proved unnecessary.

Total burdens of DDE, heptachlor epoxide and PCB residues in viable eggs and nestlings (corrected for moisture content of eggs) were calculated for each location in 1978 and compared statistically. Only arithmetic means on a wet weight basis are reported here.

Results

Moisture content and concentrations of DDE, heptachlor epoxide and PCBs were significantly lower in nestlings than those in viable eggs of Tree Swallows (Table 1). Unhatched eggs were significantly lower than viable eggs only in moisture content and fresh egg weight even when the latter parameter was corrected for the moisture difference from viable eggs. Mean concentrations of dieldrin, pp'-DDD, pp'-DDT, alpha-chlordane, oxychlordane, beta-BHC and HCB in all swallow tissues were no greater than 0.02, 0.01, 0.01, 0.02, 0.03, 0.03 and 0.01 ppm, respectively, in 1978. Those analyses were not repeated in 1979 because of the low values obtained. The coefficients of variation for duplicate determinations of parameters in Table 1 were less than five percent, except for that of PCBs in nestlings which was 14 %.

Greater relative variation in concentrations of DDE and PCBs occurred in nestlings than in viable eggs in 1978 (Table 1). This was due to nestlings having significantly higher concentrations of DDE at Fort Saskatchewan and of PCBs at Tofield and near the Gulf Oil refinery than at the other locations. Actual values can be computed from Table 2 where residue contents show that body burdens in mature nestlings were greater than the total burdens of eggs (except at Leduc). In particular, the nestling body burdens were significantly higher at Fort Saskatchewan for DDE and at Tofield and near the Gulf Oil refinery for PCBs than at other locations.

Concentrations of DDE, dieldrin, pp'-DDD, pp'-DDT, alpha-chlordane, oxychlordane, beta-BHC, PCBs and lindane in sediment samples were less than one ppb by ORF methods. Aldrin, heptachlor epoxide and HCB could not be measured in the samples because of chemical interferences. The water quality laboratory of the Inland Waters Directorate of Environment Canada in Calgary, Alberta, subsequently analyzed six samples identical to those done by ORF and confirmed the low concentrations of those chemicals except for oxychlordane and beta-BHC which were not determined. They analyzed for alpha-BHC and gamma chlordane and found both to be less than five ppb.

Discussion

Concentration data for organochlorine pesticides and PCBs in egg and nestling tissues and in sediment

TABLE 1. Mean wet weights and concentrations (± SD) of fat, moisture, organochlorine pesticide and PCB residues in fresh eggs and mature nestlings of Tree Swallows from five locations in central Alberta (all samples combined).

Year	Tissue condition	Unit Wet Weight (g)	% crude fat	% moisture	ppm wet weight[1] DDE	Heptachlor epoxide	PCB 1260	PCB 1254 1260:(1/1)
1978	62 eggs viable	1.40 ± 0.12	7.5 ± 0.5	80.7 ± 0.3	1.01 ± 0.48	0.09 ± 0.05	0.43 ± 0.09	0.46 ± 0.10
1978	39 eggs unhatched	1.04 ± 0.05	7.9 ± 0.1	76.3 ± 0.5	2.23 ± 0.97	0.07 ± 0.03	0.45 ± 0.04	0.49 ± 0.03
1978	22 nestlings live	23.0 ± 2.2	7.7 ± 0.8	70.3 ± 3.1	0.31 ± 0.38	0.02 ± 0.01	0.07 ± 0.05	0.07 ± 0.05
1979	35 eggs viable	1.39 ± 0.09	7.4 ± 1.3	80.8 ± 0.5	0.94 ± 0.51			
1979	26 eggs unhatched	1.05 ± 0.11	7.6 ± 1.7	78.2 ± 0.4	0.86 ± 0.45			

[1]Organochlorine pesticide and PCB residues of unhatched eggs corrected to same moisture content as viable eggs.

TABLE 2. Residue contents (μg) of DDE, Heptachlor epoxide and PCBs in live eggs and mature nestlings of Tree Swallows at five locations in central Alberta in 1978.

Location	DDE		Heptachlor epoxide		PCB (1254/1260)	
	eggs (n)	nestlings (n)	eggs	nestlings	eggs	nestlings
Ft. Saskatchewan[1]	0.85 (9)	20.6[2] (4)	0.04	<0.26	0.55	1.06
Ft. Saskatchewan[1]	0.85	21.9	0.04	<0.26	0.55	1.32
Chipman	2.53 (9)	1.06 (5)	0.18	0.53	0.88	1.32
Tofield	1.25 (19)	2.41 (3)	0.13	0.53	0.53	2.64
Gulf Oil Refinery	0.99 (10)	1.85 (3)	0.08	0.79	0.59	4.23
Leduc	1.43 (15)	1.06 (3)	0.21	0.53	0.66	0.64

[1]Differences due only to replication of chemical analysis.
[2]Location-specific residue concentration multiplied by values of mean nestling weight and egg to nestling moisture ratio from Table 1.

samples suggested that Tree Swallows would not be seriously contaminated with those chemicals by consuming insects in central Alberta. In fact, the concentrations for DDE, PCBs and some other residues found in Tree Swallow eggs were lower than the background concentrations of DDT and its metabolites in eggs of Mountain Bluebirds, *Sialia currucoides,* in areas not sprayed with DDT (Henny et al. 1977). Concentrations of DDE and PCBs in Tree Swallow nestlings were similar to or somewhat lower than those in Clapper Rails, *Rallus longirostris,* (Klaas and Belisle 1977), several years after DDT spraying of their habitat was stopped. However, Enderson et al. (1982) reported 32.8, 33.5 and 0.42 ppm of DDE, total organochlorine pesticides and PCBs in an adult Tree Swallow sample collected in Colorado. Such data for adult Tree Swallows in Canada have yet to be reported.

Raptors, such as the endangered Peregrine Falcon, *Falco peregrinus,* get part of their body burdens of organochlorine pesticide residues from consuming prey species like the Tree Swallow (R. W. Fyfe, CWS, personal communication). For several migratory raptor and prey species it is now important to determine how much of the adult contamination from organochlorine pesticides occurs in the breeding grounds and how much in the overwintering grounds of Central and South America. The significantly greater body burdens of nestlings compared to eggs for DDE and PCBs reported here for some locations in central Alberta suggests that some Tree Swallows are still being contaminated in Canada, and might contribute to toxic chemical accumulation in Peregrines here.

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Klaas, E. E., and **A. A. Belisle.** 1977. Organochlorine pesticide and polychlorinated biphenyl residues in selected fauna from New Jersey salt marsh 1967 vs. 1973. Pesticide Monitoring Journal 10: 149–158.

Reynolds, L. M., and **T. Cooper.** 1975. Analysis of organochlorine residues in fish. Water Quality Parameters, American Society of Testing and Materials STP 573. Pp. 196–205.

Received 18 April 1983
Accepted 15 October 1983

News and Comment

Editor's Report for 1983: Volume 97

In 1983, the publication of *The Canadian Field-Naturalist* ran behind schedule and 96(4) was marked 18 April and 97(1) 16 September. The remainder of the volume appeared as follows: 97(2) 9 January, 97(3) 6 March and 97(4) 9 April 1984. Despite these delays, the journal is expected to be back on its regular schedule by the end of 1984.

The number of manuscripts submitted in 1983 was 140, two more than 1982 and four above 1981 (see Editors report for 1982: *The Canadian Field-Naturalist* 97(2): 229–230). Sixty-three of these have been accepted but final totals for the year are incomplete. Of 138 manuscripts submitted in 1982, 98(72%) have been accepted for publication.

The number of manuscripts published in *The Canadian Field-Naturalist* volume 97 is given by field in Table 1. The number of pages of research (44 articles and 43 notes) was 374 (302 pages of articles and 72 of notes). News and Comment (including notices, Editor's Report, Annual Report of Council, tribute to J. D. Soper, and one special article) accounted for 39 pages. Book Reviews (including New Titles) 57 pages, and the additional notices (Instructions to Contributors and club publications advertisement) for 4.

The number of reviews and new titles published were: zoology 26 and 154, botany 11 and 52, environment 10 and 88, miscellaneous 7 and 56 and young naturalists 0 and 64, for a total of 54 reviews and 414 new titles. An additional analysis by the Book Review editor follows this report.

Thanks are due to associate editors Stan Van Zyll de Jong and Bill Pruitt (mammals), Tony Erskine (birds), Charles Jonkel (predator-prey relationships), Don McAllister (fish), Stephen Smith (insects), Ed Bousfield (invertebrates) and Charley Bird (plants).

TABLE 1. Number of manuscripts published in *The Canadian Field-Naturalist* 97(1983) by major field of study.

Subject	Number of Manuscripts Total	(Articles & Notes)
Mammals	25	(13 + 12)
Birds	27	(12 + 15)
Amphibians and Reptiles	3	(1 + 2)
Fish	13	(9 + 4)
Invertebrates	1	(1 + 0)
Plants	18	(8 + 10)
Total	77	(44 + 43)

George La Roi continued to co-ordinate *The Biological Flora of Canada*. The following additional referees are gratefully acknowledged for providing reviews of manuscripts in 1983:
C. D. Ankey, G. W. Argus, P. W. Ball, J. C. Bartonek, J. C Barlow, J. I. Bassett, I. Bayley, J. Bedard, F. C. Bellrose, G. Black, J. S. Bleakney, R. G. B. Brown, D. F. Brunton, C. H. Buckner, J. Burger, D. G. Busby, C. A. Campbell, L. Carbyn, A. Ceska, G. Chapdelaine, B. Coad, W. J. Cody, P. J. Colby, F. Cooke, M. Crête, E. J. Crossman, A. Cyr, H. Danks, J.-L. DesGranges, E. H. Dunn, M. I. Dyer, R. Y. Edwards, D. Euler, R. M. Evans, D. J. Faber, J. B. Falls, E. B. Fenton, C. D. Fowle, B. Freedman, L. H. Frederickson, A. J. Gaston, V. Geist, F. E. Gilbert, J. Gilhen, W. E. Godfrey, J. B. Gollop, S. W. Gorham, P. K. Gregory, C. G. Gruchy, F. Hammerstrom, V. Harms, F. H. Harrington, C. F. Henny, T. Herman, L. V. Hills, M. Hoefs, G. L. Holroyd, C. S. Houston, D. J. T. Hussell, W. B. Illman, R. Ireland, R. D. James, P. A. Keddy, L. Keith, D. Keppie, R. W. Knapton, M. V. Legendre, L. Licht, A. R. Lock, H. G. Lumsden, C. D. MacInnes, G. Mackie, D. F. McAlpine, R. A. McArthur, S. D. Macdonald, M. K. McNicholl, L. D. Mech, R. I. G. Morrison, T. Mosquin, S. Nepszy, B. Ogilvie, M. J. Oldham, H. Ouellet, P. A. Pearce, W. Pepper, W. B. Preston, A. Reed, D. A. Rivard, R. J. Robertson, J. P. Ryder, D. B. O. Saville, M. W. Shoesmith, F. W. Schueler, G. Scotter, F. Scott, J. M. Shay, N. Simons, D. A. Smith, J. N. M. Smith, W. E. Southern, R. J. Speer, R. R. P. Stardom, P. R. Stepney, L. G. Sugden, R. Taylor, W. T. Thelfall, E. Tull, S. P. Vander Kloet, N. A. M. Verbeek, R. Wassersug, P. J. Weatherhead, R. D. Weir, M. W. Weller, W. F. Weller.

E. Wilson Eedy continued as Book Review editor, and Harvey Beck again compiled the Index. Bill Cody added a 35th consecutive year as Business Manager. Barbara Stewart filled a void by assuming the role of assistant to the editor and took over the arduous task of processing incoming manuscripts, routing them to the recommended reviewers, preparing acknowledgements, and filing. Louis L'Arrivée ably served as copy editor by proof-reading galleys and Thérèse Lapierre, Vertebrate Zoology Section, National Museum of Natural Sciences, typed a portion of the correspondence. M.O.M., Ottawa, printed the journal and special thanks are due to Emil Holst and Eddie Finnigan and the rest of the staff involved in producing *The Canadian Field-Naturalist* for their efforts.

The National Museum of Natural Sciences, National Museums of Canada, continued to provide space and a portion of the time for editing and I am particularly indebted to Henri Ouellet, Chief Vertebrate Zoologist, and C. G. Gruchy, Assistant Director, Research and Operations, for their support. No less is my appreciation to Ron Bedford, Chairman, and to other members of the Publications Committee, and to the Council of the Ottawa Field-Naturalist for continuing encouragement during a rather trying year. Many authors made a special effort to respond to long processing delays with good will and these, and others less restrained, should soon be pleased to note a marked reduction in response time. When this report appears, the backlog should finally have been overcome. I am indebted to those who have pointed out the wide spectrum of readers reached by *The Canadian Field-Naturalist* as demonstrated by the number and geographic dispersal of the reprint requests they have received for articles and notes published here.

FRANCIS R. COOK
Editor

Book-Review Editor's Annual Report (Volume 97)

It seems that every year there is an increasing number of books on the market. The value of listing these New Titles and of providing reviews to indicate their usefulness to field naturalists thus increases. The difficulty in identifying appropriate reviewers and ensuring reviews are completed on time also grows. New reviewers are greatly appreciated as are the expeditious actions of the many specialists who continuously help us keep up with the expanding literature base.

In 1983 *The Canadian Field-Naturalist* listed 414 New Titles. This is an increase of almost 50% from five or six years ago. The number of complimentary books sent to us by publishers has climbed to 98, an increase of 36% over 1978 but a slight reduction from 1982. Both areas of reviews completed (66) and published (54) have however decreased slightly from previous years. This emphasizes the need for quick reviews and more voluntary reviewers. The Book-Review Editor now has some 50 to 60 books available for review which have been published since 1980. Anyone wishing to prepare reviews should contact the editor and provide a concise description of their interests and expertise.

WILSON EEDY

Book Review Editor, RR 1 Moffat, Ontario L0P 1J0

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC): 1984 Update

Cook and Muir (1984. *The Canadian Field-Naturalist* 98(1): 63–70) have outlined the history and progress of The Committee on the Status of Endangered Wildlife in Canada (COSEWIC), a committee of representatives from federal, provincial and private agencies which assigns national status to species at risk in Canada, and listed attendance and designations until the end of December 1983.

The 1984 annual meeting was held 4 April with representatives from wildlife departments of British Columbia, Alberta, Manitoba, Ontario and Quebec attending. Federal representatives were from Canadian Wildlife Service, Parks Canada, National Museum of Natural Sciences (National Museums of Canada), Department of Fisheries and Oceans. Non-governmental representatives were Canadian Nature Federation, Canadian Wildlife Federation and World Wildlife Fund Canada.

The committee's decisions, based on status reports and agreed status definitions (see Cook and Muir 1984), taken at this meeting were as follows:

Rare:
Green Dragon, *Arisaema draconitium*
Shumard Oak, *Quercus shumardii*
Hop Tree, *Ptelea trifoliata*
Prothonotary Warbler, *Protonotaria citrea*
Eastern Bluebird, *Sialia sialis*
Common Barn-owl, *Tyto alba*
Western Woodland Caribou (mainland west of James Bay), *Rangifer tarandus caribou*
Queen Charlotte Islands Ermine, *Mustela erminea haidarum*

Threatened:
Plymouth Gentian, *Sabatia kennedyana*
Water Willow, *Justicia americana*
Giant Helleborine, *Epipactis gigantea*
Mosquito Fern, *Azolla mexicana*
Henslow's Sparrow, *Ammodramus henslowii*
Maritime Woodland Caribou (south of the St. Lawrence), *Rangifer tarandus caribou*

TABLE 1. Distribution of COSEWIC Designated Species as of April 1984.

	Birds	Mammals (terrestial)	Mammals (marine)	Fish	Amphibians & Reptiles	Plants	Total
Rare	12	7	1	8	—	4	32
Threatened	6	3	1	1	—	8	19
Endangered	5	4	3	1	1	7	21
Extirpated	—	2	—	—	—	—	2
Extinct	—	1	—	—	—	—	1
Not in any Category	6	7	—	1	—	1	15
Totals	29	24	5	11	1	20	90

Endangered:

Southern Maidenhair Fern, *Adiantum capillus-veneris*

Pink Coreopsis, *Coreopsis rosea*

Cucumber Tree, *Magnolia acuminata*

Pink Milkwort, *Polygala incarnata*

Extinct:

Dawson Woodland Caribou (Queen Charlotte Islands), *Rangifer tarandus dawsoni*

Not in any category:

False Mermaid, *Floerkea proserpinacoides*

Bald Eagle, *Haliaeetus leucocephalus*

Northeastern Woodland Caribou (East of James Bay, North of the St. Lawrence), *Rangifer tarandus caribou*

Newfoundland Woodland Caribou (Newfoundland), *Rangifer tarandus caribou*

Mountain Beaver, *Aplodontia rufa*

The distribution of the 90 species thus far considered by COSEWIC is given by category in Table 1. The additions were formally announced on 10 July 1984 by J. Anthony Keith, Chairman of COSEWIC, at the Forty-eighth Federal-Provincial Wildlife Conference in Timmins, Ontario.

DALTON MUIR

Secretary, COSEWIC, Ottawa, Ontario K1A 0E7

Grants Available for Canadian Bird Research: The James L. Baillie Memorial Fund

The James L. Baillie Memorial Fund for Bird Research and Preservation invites applications for grants to support projects on Canadian birds in 1985. While grants have previously been restricted to Ontario, the Fund will now consider applications from other parts of Canada.

The Fund's aim is to encourage field studies by amateur naturalists and to support projects which increase or disseminate knowledge of birds in their natural environment and/or contribute to their preservation. Priority will be given to projects which utilize the efforts of volunteer naturalists in conducting research or fieldwork and to applicants who have little or no access to other sources of support.

Two types of grants will be offered in 1985: (a) Project Grants and (b) Ontario Atlas Fieldwork Grants. Any project which has a volunteer component and otherwise meets the Fund's objectives is eligible for a type (a) grant. Type (b) grants provide partial support for travelling expenses to remote central and northern areas for fieldwork on the Ontario Atlas of Breeding Birds. Requests for funding of atlas projects elsewhere in Canada should be directed to type (a) grants.

Grants do not normally exceed $1000. Applications for Project Grants are due by 31 December 1984 and for Atlas Fieldwork Grants by 28 February 1985. All applications should be submitted on forms obtainable from the Secretary, The James L. Baillie Memorial Fund, c/o Long Point Bird Observatory, P.O. Box 160, Port Rowan, Ontario N0E 1M0.

The James L. Baillie Memorial Fund awarded five Project Grants totalling $1475.00 and nine Ontario Atlas Fieldwork Grants totalling $3420.80 in 1984. The Fund is financed in part from proceeds of the Baillie Birdathon. Donations to the Fund are tax deductible and may be sent to the address given below.

MARTIN K. MCNICHOLL

Secretary, The James L. Baillie Memorial Fund for Bird Research and Preservation, c/o Long Point Bird Observatory, P.O. Box 160, Port Rowan, Ontario N0E 1M0.

The Alfred B. Kelly Memorial Fund of the Province of Quebec Society for the Protection of Birds

Annual Research Grants up to $1000 will be available for studies pertaining directly to Quebec ornithology. Applications will be accepted from any interested person regardless of place of residence.

Applications must be postmarked by 1 March, 1985. Applicants will be notified of the committee's decision by 15 April, 1985.

For application forms write to:

MARIANNE G. AINLEY
P.Q.S.P.B. Research Committee
4828 Wilson Avenue
Montreal, Quebec
Canada H3X 3P2

Errata: COSEWIC Articles, 98(1): 63–133.

Page 70, line 5: "asked to state which", should read "asked to state in which";

Page 71, 2nd paragraph, line 2: "of the basis", should read "on the basis."

Page 73, 2nd paragraph, last line of Acknowledgments: "advice information", should read "advice and information."

Page 73, Table 2: Paddlefish scientific name: "*Polydon spathula*" should read "*Polyodon spathula*."

Page 73, Table 2: Gravel Chub scientific name: "*Hybopis x-punctatata*" should read "*Hybopsis x-punctata*."

Page 74, last committee member, line 6 of 2nd column: "Dr. M.A. Brigg", should read "Dr. M.A. Bigg."

Page 74, Table 3: Northern Brook Lamprey, scientific name: "*Ichthyomyson fossor*" should read "*Ichthyomyzon fossor*."

Page 74, Table 3: Mimic Shiner, scientific name: "*Notropis volicellus*" should read, "*Notropis volucellus*."

Page 74, Table 3: Bluntnose Minnow, scientific name: "*Pimiphales notatus*", should read "*Pimephales notatus*."

Page 78, Limiting Factors, paragraph 2, line 3: "Alewife (*Alosa pseudoharangus*)" should read "Alewife (*Alosa pseudoharengus*)."

Pages 80, 91, 104, 110: B. Parker is no longer with Beak Consultants. He is now with Amik Resources Groups, Suite 112, 5955 Airport Road, Mississauga, Ontario L4V 1R9.

Page 82, line 7, "Waterweed (*Anacharus* sp)" should read "Waterweed (*Anacharis* sp.)."

Page 84, 2nd paragraph, line 8; 4th paragraph, line 11; 7th paragraph, lines 5 and 10: "Redmon (1964)" should read "Redmond (1964)."

Page 85, Literature Cited, 15th citation: "Redmon" should read "Redmond."

Page 86, Distribution, lines 2 and 3: "An anadromous population recorded"; should read "An anadromous population has been recorded."

Page 91, 1st paragraph, line 7: "Emerald Shiner (*Notropis otherinodes*)", should read "Emerald Shiner (*Notropis atherinoides*)."

Page 97, Editor's note, the submission and acceptance refers to the submission of the original status report to the Subcommittee and its acceptance by COSEWIC, not to the dates given for the edited copy for the journal. The latter, however, was based solely on the original.

Page 103, Acknowledgments, line 4: "Gordon Greese and Brent Coole", should read "Gordon Green and Brent Cooke."

Page 110, Population Size and Trends, line 5: "(Parker and McKee 1989)", should read "(Parker and McKee 1980)."

Page 115, 1st line: "Threespine Sticklebacks (*Gasterosteus aculateus*)", should read "Threespine Sticklebacks (*Gasterosteus aculeatus*)."

Page 115, 2nd paragraph, line 4: "Riemchen 1973", should read "Reimchen 1973."

Page 120, in Protection lines 6 and 7: "(an Ecological reserve)" should read "within Naikoon Provincial Park)."

R. R. CAMPBELL
Chairman, Fish and Marine Mammal Subcommittee, COSEWIC
Fisheries and Oceans Canada, 200 Kent Street, Centennial Towers, 12th Floor, Ottawa, Ontario K1A 0E6

Additional Errata for 98(1)

Table of Contents 98(1), outside back cover, fifth article: "Groéland" should read "Goéland."

Table of Contents 98(1), inside back cover, second article: "R. R. Cambell" should read "R. R. Campbell."

New Titles 98(1), page 149: "Federal : tame animals gone wild"; should read: "Feral : tame animals gone wild."

FRANCIS R. COOK
Editor

Book Reviews

ZOOLOGY

Seasons of North American Birds: engagement calendar 1984.

Photographs by Jean-Louis Frund. Text by Odas White. 1983. Whitecap Books (distributed by Firefly Books, Scarborough). 100 pp., illus. $12.95.

This calendar book, as suggested by the title, presents some 53 species as they are found in Canada in the respective seasons. The photographs have been carefully selected to present the birds in representative habitats and activities for each particular season. The birds, with few exceptions, such as a Snow Goose staging area in Quebec, are depicted singly or in small groups at close enough range to be easily recognized. The clarity of the photographs and poses selected are excellent.

For each week there is a bird photo, on the left, and a calendar/diary on the right. The calendar pages have a daily column with 12 (8 am to 8pm) of lines. A small monthly calendar and space for birding notes at the bottom, complete the page. The calendar pages have a cut-off corner for easy access.

I would have some difficulty putting notes in the narrow columns alotted for each day. My own preference is for horizontal daily spaces without hourly divisions. The book itself is well produced with a hard cover that will preserve it better than the usual surlox or wire ring binding. The photographs are both taken and printed with excellent quality.

The short write-ups on each species provide interesting insights into the seasonal activities of the species and their natural history. The author increases the interest by expressing the photographer's enthusiasm on suddenly attaining a rare shot, whether it is an unusual species or a common bird in an unparalleled pose. Although short, these write-ups give a feeling of affinity to anyone who has spent hours searching for and photographing birds.

WILSON EEDY

IEC Beak Consultants Ltd., 6870 Goreway Drive, Mississauga, Ontario L4V 1P1

Where to Find Birds in New York State: the top 500 sites

By Susan Roney Drennan. 1981. Syracuse University Press, Syracuse. 672 pp., 106 maps. Cloth U.S. $38.00; Paper $18.95.

Olin Sewall Pettingill, Jr., certainly started something when in 1951 he published *A Guide to Bird Finding East of the Mississippi.* Pettingill wished his book to bring to persons the country over a greater awareness of the endless opportunities for bird finding in all states. A perusal of the American Birding Association's sales list shows that a majority of the states have at least some regional coverage on where to find birds and several have statewide coverage. A sampling of some of the most noteworthy includes Lane's birder's guides to southeastern Arizona, southern California, eastern Colorado, Florida, Texas coast, and Rio Grande Valley; a few from states bordering Canada: *Guide to Bird-finding in Washington, Birder's Guide to North Dakota,* and *A Birder's Guide to Minnesota*; and several from Canadian provinces; *Where to Find Birds in British Columbia,* four regional guides for Manitoba, *A Birdwatcher's Guide to Atlantic Canada, Where to Find Birds in Nova Scotia,* and *Bird-finding Guide to Ontario.* Birders are apparently getting what they desire, and now New York, which previously only had regional coverage, has a statewide guide.

The book is divided into two parts, the first a small section that discusses New York's Avian Records Committee and rare bird alerts, ornithological collections and libraries, and physiographic regions. The major second part covers the 10 regions used for reporting bird sightings in New York's bird journal, *The Kingbird.* Chapters on seabirds and pelagic birding, and hawk migration also are included. A three-page bibliography and a 13-page special species status and site index concludes the volume. An integral feature is the inclusion of 106 site maps. These maps differ considerably in scope and detail although most appear to be useful. The addition of a scale would have been a decided benefit to the user.

While I commend Ms. Drennan for her tremendous effort in assembling this valuable information, I have several criticisms. I have always felt that along with a thorough knowledge of the subject matter, anyone who undertakes writing a book should have a feel for the language and fundamental grasp of grammar.

Although another reviewer of this book found its style to be engaging and conversational, I found Ms. Drennan's florid style an English teacher's nightmare. In some sections the reader must wade with great difficulty through jungles of commas and dangling clauses. A tightening of the style could have reduced the size of the book (and its considerable price) as could have the elimination of the author's pontifications on the wonders of the natural order. Inclusion of considerable natural history information sets this guide off from others but how much is enough?

In general, more organization would have improved the book's usefulness. More subheadings would help people locate the information they want. There is no consistent ordering of information for an area with the area's description, ownership and history, natural history information, directions, and birding information more or less all blended together. The directions especially could have been set out from the other information. I found many of the directions rather inconsistent and unclear. Mileage from a major town or intersection for all sites would be helpful, and a regional map showing all sites within the region would have been informative. Areas within a region do not appear to be presented in any logical order.

Just the little thumbing and reading I have done is fraying and curling the cover of my paper copy. Perhaps a different binding would help the book stand up to in-and-out-of car use. The $38.00 hardbound copy is an expensive option.

Even with my criticisms taken into account, birders who travel in New York State will probably need a copy. Because all environments are in a constant state of change, I hope that Ms. Drennan and the authors of other state guides find time to periodically update their works.

NOEL J. CUTRIGHT

Wisconsin Electric Power Company, 231 West Michigan, Milwaukee, Wisconsin 53201

Gulls: A guide to identification

By P. J. Grant. 1982. Buteo Books, Vermillion, South Dakota and T. & A. D. Poyser Ltd., Calton, Staffordshire, England. 280 pp., illus. U.S. $32.50.

This book is based mostly on material published by the author in a series of five papers in British Birds between 1978 and 1981. The book title is somewhat misleading because it considers only 23 species of gulls (about half the world total) which are found in "Europe, the Middle East and eastern North America". Oddly though, the Herring Gull (*Larus argentatus*) and the Ring-billed Gull (*L. delawarensis*), to mention only two included species, also occur commonly in western North America. Similarly, the Glaucous Gull (*L. hyperboreus*), Sabine's Gull (*Xema sabini*), Ross's Gull (*Rhodostethia rosea*) and others considered, occur in the Siberian Arctic, not what this reviewer would consider part of Europe. I think the term Holarctic is a better term to describe the distribution of species covered.

The author places the gulls into five groups, each containing species with similar characteristics, especially in their immature plumage, which, as the author correctly notes, is the stage that most people find they have identification problems. Each group is introduced by a general account of topographic characters, with drawings by the author, distribution and body measurements (lengths of wing, tail, bill and tarsus). The latter are taken from Dwight's 1925 classic monograph *The Gulls of the World*. The detailed species accounts within each group include identification clues, an ageing summary (based on plumage colour), details and figures of each plumage stage and a distribution map.

Following the 149 pages of text are 376 very good black and white photographs of the 23 species. The photos show gulls standing, flying, swimming, in flocks, feeding, and some on their nests. They are designed to illustrate many of the features discussed in the species account section. A brief reference section lists 12 articles related to the subject matter of the book.

My major problems with the book stem from its British slant. The terminology used in some of the topography and plumage sequences will perhaps be confusing to many North American readers. Some examples: Juvenile is used instead of juvenal; the white spots on the tips of primaries that most of us call windows are termed mirrors; crown is called cap on page 18 then crown on page 19 (!) and the primaries are numbered distally instead of proximally. The plumage sequences are very puzzling. I can't understand how a bird that hatches in July is not considered to be in its first summer of life at that time. Grant discounts the hatching summer as the first and considers that a first summer bird (one that is actually in its second year of life) moults into its second winter plumage! This means for instance that a bird that is in its fourth year of life is in its third summer plumage.

Scientific and common names are largely in agreement with the recent A.O.U. Supplement to the Check-List on North American Birds (Auk 99(3), 1982). The two exceptions are calling *L. canus* the Common Gull instead of the Mew Gull and placing Sabine's Gull in the genus *Larus* rather than *Xema*.

The physical appearance of the book is initially pleasing. The text is easy to read, the black and white photographs are well produced and Grant's drawings adequate. Its 15 × 23 cm size renders it suitable for easy storage in a large pocket or packsack. After reading the book however, I found that the inside stitching was failing and the text paper was not waterproof. I thus do not advise any purchasers of this book to consider it a field guide to the gulls.

This book realizes its objectives in covering the complexities of identifying and ageing some species of this very interesting and commonly seen group of birds. The author requests corrections to the text, illustrations and maps and solicits new photographs for inclusion in what will be a welcome second edition. I hope next time the author considers in more detail the geographical variation in plumage characters that occur in such widely distributed species as the Herring, Glaucous and Sabine's Gulls.

JOHN P. RYDER

Department of Biology, Lakehead University, Thunder Bay, Ontario P7B 5E1

Mammifères du Québec et de l'est du Canada, tomes 1 et 2.

By Jacques Prescott and Pierre Richard. 1982. Editions France-Amérique, Montréal. xiii + 199 pp., illus. and 230 pp., illus. $11.95 each.

These attractive, pocket-sized (11 × 18 cm) volumes provide descriptions, distribution, and life history information on 91 species of terrestrial and aquatic mammals of Quebec and eastern Canada. Another 16, occurring sporadically or in small numbers in this region, are listed with brief comments in the back of each volume (7 in Vol. I, 9 in Vol. II). Volume I deals with marsupials, insectivores, bats, lagomorphs and rodents; Volume II with carnivores, pinnipeds, artiodactyls and whales.

Both volumes are preceded by a nearly identical introduction and can be used independently of each other. Volume I has, moreover, a brief section on how to observe mammals, a list of rare and endangered species in the region, and a glossary. A carefully selected bibliography and a set of drawings of mammal tracks conclude each volume.

The general characteristics of the nine orders represented in the region precede the individual species accounts. Each species account is presented in a standardized manner giving common and scientific names, information on distribution, external measurements, weights, diagnostic characters, habitat, reproduction, longevity, predators, food habits, and behaviour. The location in the text of each topic is indicated by small pictographs in the left hand margin, which I did not find very effective. The distribution in eastern Canada is shown on a small map and, in most cases, each species is illustrated by a colour photograph, with a sprinkling of supplementary black and white drawings throughout the book.

The information is accurate, succinct, and well presented. The quality of the illustrations is generally good, although in some cases photographs are those of dead or moribund individuals (e.g. the moles on p. 29 and 33). A few of the photographs do not represent that species in the accompanying text (e.g. the bats on p. 43 and 45 and the shrew on p. 13). The book is aimed at a general audience and should appeal and be useful to a broad spectrum of people interested in mammals.

C. G. VAN ZYLL DE JONG

National Museum of Natural Sciences, National Museums of Canada, Ottawa, Ontario K1A 0M8

Birds of the St. Croix River Valley: Minnesota and Wisconsin

By Craig A. Faanes. 1981. North American Fauna, No. 73. U.S. Department of Interior, Fish and Wildlife Service, Washington. 196 pp.

The North American Fauna series, which begun in 1889, includes monographs and other reports of scientific investigations relating to birds, mammals, and herpetofauna. Faanes' report upholds the fine tradition of the series.

The St. Croix River Valley encompasses nearly 11 550 km² in east-central Minnesota and northwestern Wisconsin. Counties covered include Chisago, Pine, and Washington in Minnesota and Burnett, Douglas (part),

Pierce, Polk, and St. Croix in Wisconsin. The first 24 pages are devoted to an abstract, and a discussion of climate, geology, physiography and land use, habitats and bird distribution, and methods, terminology, and nomenclature. The book concludes with five pages of references, an appendix of plant names, and a bird species index. The bulk of the book gives accounts for 314 species. Data are presented on the migration period, nesting season distribution, winter distribution, relative abundance, and habitat use.

The author gathered firsthand experience with the Valley's birdlife by conducting extensive surveys of avian distribution and abundance from 1966 to 1980. These results were supplemented with Christmas Bird Count and U.S. F&WS Breeding Bird Survey data, published field records, and unpublished field notes.

A wide range of vegetational communities are present in the Valley. Nineteen distinct habitat categories are discussed in terms of size, distribution, floral characteristics, and characteristic breeding birds. Because of the changes in natural habitats due primarily to urban expansion and agricultural production, abundance and distribution of bird species have been influenced. In the Valley, seven species are endangered, eight are threatened, and 29 are watch or priority status in either or both states.

Because the Fauna series is intended primarily for professional readers, the book's style is very straight forward and crisp with virtually no errors. The author has certainly assembled a wealth of information and I agree with the author in the belief that this information will all undoubtedly be of considerable value to land managers, land use specialists, and ornithologists interested in assessing current and projected habitat alterations on the avifauna of this Valley.

NOEL J. CUTRIGHT

Wisconsin Electric Power Company, 231 West Michigan, Milwaukee, Wisconsin 53201

The Barn Owl

By Derek Bunn, Tony Warburton, and Robert Wilson. 1982. Buteo Books, Vermillion, South Dakota, 264 pp., illus. U.S.$32.50.

To quote the authors themselves in the preface, Derek Bunn, Tony Warburton, and Robert Wilson should certainly have "no regrets about pooling . . . knowledge and collaborating in the production of this book." This fine effort detailing the biology of the Barn Owl (*Tyto alba*) is apparently equivalent to some 38 years of tedious observations by a single person.

The book is written and published in the same fashion as its forebears, e.g. Hen Harriers (*Circus cyaneus*), Peregrine Falcons (*Falco peregrinus*), to name but a few, by British authors. The nine chapters cover the following subjects: description and adaptations, voice, general behaviour, food, breeding, movements, factors controlling populations and possible conservation measures, distribution in the British Isles, and finally folklore. The text is accompanied by a colour frontispiece, 31 pertinent black and white photographs, 11 figures and 39 tables, and a dozen or so elegant ink drawings by artist Ian Willis.

I personally liked having the tables interspersed throughout the text rather than bunching them at the end as has been done in similar published works. Structurally, Table 18 on p. 150, which denoted causes of death in Dutch Barn Owls, might have been more strategically placed in Chapter 7 on causes of mortality, or at least referred to there. One might also argue that the book's title is not definitive enough due to a heavy reliance on British data. Certainly, Chapter 8 on the distribution of the Barn Owl in Britain is not likely to generate much interest in non-British readers. Overall, though, the authors do make sufficient reference to foreign published material in other chapters to warrant such an all-encompassing title. The book is virtually free of typographical and grammatical errors, except for one small point, i.e. the singularizing of the word "data" on no less than six occasions.

The authors provide a good case against using pellets as a method of assessing daily food intake (p. 98), but I was surprised that no reference was made to Gary Duke's excellent research on pellet egestion in owls at the University of Minnesota. I am also certain that owls can rotate their heads through 270° and not just 180° (p. 35). The mechanism by which owls make clicking sounds must still remain controversial, especially since Robert Nero in his book *The Great Gray Owl* (Smithsonian Institution Press, Washington, D.C.) seems convinced that the snapping of the bill is responsible for the sound. In any event, the importance of vocalizations during the breeding season is soundly underlined in an entire chapter devoted to the subject. The Barn Owl must surely be the only species which snores during copulation!

The book prompts many interesting unanswered questions. Why is the Barn Owl white? Do they store food outside the breeding season? Do Barn Owls deliberately move their ear conches? Many ornithologists will be especially intrigued by the authors' obser-

vations of older nestmates actually feeding their younger siblings in the nest.

Overall, the book, written in layman's terms, shows much consideration for both the reader and the Barn Owl. Appendix 3 on p. 249 is must reading for anyone attempting to study owls in the wild. The authors' assessment of the usefulness of Barn Owls (p. 102), as well as nestbox programs for this species (p. 187), is refreshingly honest. All of the above make this book a substantial contribution to the library shelves of educators, managers and researchers dealing with wildlife.

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BOTANY

Wildflowers of the Yukon and Northwestern Canada including adjacent Alaska

By John G. Trelawny. 1983. Gray's Publishing, Sidney, British Columbia. 212 pp., Illus. $19.95.

This book contains a collection of 329 colour photographs of plants of the Yukon and adjacent areas. This is about one quarter, and certainly the most showy part of the flora of the region. The pictures which were taken by 14 different photographers including the author, are each accompanied by a descriptive paragraph together with a note on the habitat and range of the species. As with most collections of photographs, perhaps taken with different films, and certainly under different lighting conditions, there is some variation in the end result. The colour separations used in the printing process may also have affected the resulting published pictures. Thus for a few, the yellows may be slightly orange, or with others, the backgrounds too dark. To visitors to Canada's northwest however, this book will be a treasure of colour to take home as a memory of some of the flowers they have seen in their travels. To those who are planning a trip, the book will give a preview, and to those who cannot travel, something to think about. It is a welcome addition to the books on the natural history of our country.

There is no key to species such as one would find in a standard flora, but there is a useful key based on flower shape and colour. There is also a glossary which is partly illustrated, thus making it easier to understand some botanical terms. A short bibliography and an index complete the volume.

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A Field Guide to the Sedges of the Cariboo Forest Region, British Columbia

By Anna Roberts. 1983. Land Management Report No. 14. Province of British Columbia, Ministry of Forests, Victoria. 89 pp., illus. Free.

Rarely is a publication produced which attempts to popularize and simplify the identification of sedges, a group of plants often considered to be the most difficult in our flora. This publication has been designed to facilitate the identification of sedges likely to be found by resource managers in the middle portion of the Fraser River watershed in south-central British Columbia. Instead of the usual organizaiton of species seen in floristic treatments, species are grouped together according to the habitats in which they occur (grassland, dry forest, wet forest, wetland, and subalpine-alpine). The limitations inherent in this type of classification are recognized and discussed by the author. In cases where a species is known to occur in more than one of the habitat classes, it is listed under each type. Once the appropriate habitat type has been chosen by the user, a key, descriptions, and illustrations of the common sedges in that type are provided.

An introductory section provides general information on the location of the Cariboo Forest Region, and also discusses the importance of sedges in ecological processes and as natural forage for livestock. The basic morphological differences among grasses, rushes, and sedges are briefly treated.

Five chapters deal with the sedges found in the habitat classes mentioned above. General features of these classes are provided, including soil, vegetation, and rainfall characteristics. A list of the sedge species, including a status designation for each, and a key to the more common species within each zone are provided. The common species are described and provided with a habit sketch and inflorescence enlarge-

ment illustration. Size features, inflorescence characters, and vegetative features are included in the descriptions. These are supplemented by discussions of similar species, status, and uses. Fifty-six of the 84 species of *Carex* known to occur in the region are fully treated. The illustrations generally convey the appearance of the species accurately, although they tend to be quite coarse.

It is unfortunate that the "less common" or "rarely encountered" species are not keyed, illustrated, or described. For most of these, a name simply appears in a list, with little or no indication of what that species looks like. In this regard, a number of inconsistencies appear within the text. On page 25, one of the "less common" species (*Carex peckii*) is included in the key to wet forest species. Also in this section, *Carex sprengelii* is discussed as a similar species to *C. capillaris*, but it is not listed at the beginning of the chapter at all. The same is true for *Carex atrosquama,* discussed under *C. norvegica.* In the section on wetland sedges, no key is provided for the large and conspicuous aquatic sedges. These are almost certainly among the first sedges that any field worker encounters and recognizes. They are described and illustrated, but a key would have greatly facilitated their identification. There is also some inconsistency in the illustrations. In some cases, enlargements of the perigynium are provided, while in others, these are omitted. The illustrations would have been of greater value if this feature had been included in all of them.

An illustrated glossary provides a very useful aid to explain terms used within the text. Although the text has been written with a minimum of technical terminology, it is inevitable that some such terms must be included, and this glossary amply explains them. An additional feature of this publication, which should be of particular interest to *Carex* enthusiasts, is the inclusion of a key to the difficult *Carex macloviana* complex, based on a taxonomic revision of this group by Richard Whitkus.

The treatments of species and the features used in the keys are generally accurate, and this publication should prove to be easy to use. For a relatively small *Carex* flora such as that found in the Cariboo Forest Region, the arrangement of species by habitat is also reasonably workable. The text is relatively free of typographical errors. I might point out, however, that the 8½" × 11" (21.5 cm × 28 cm) format hardly qualifies as "Field Guide" size, as far as portability is concerned. Nevertheless, this publication should be a useful aid to field botanists and resource managers in interior B.C. I believe it will achieve its aim of enhancing the field identification of sedges in its area of coverage. It could have had wider appeal, however, if all of the species in the region had been treated fully.

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Flora of Iceland

By Askel Löve. 1980. Almenna bōkafélagid, Reykjavik, Iceland. 403 pp. illus. $20.00.

This is a pocket-sized flora designed especially for visitors to Iceland. In it 522 species and 28 subspecies are illustrated by the fine line drawings of Dagny Tande Lid, and in addition 19 are reproduced in color from water-color paintings.

The text, which is in the form of short keys and descriptions of the families, genera, species, and subspecific taxa, together with an indication of habitat, frequency, and location on the island, is essentially an updated translation from Icelandic of its forerunners, *Islenzk feroaflora* and *Islenzkar jurtir.* The nomenclature is up-to-date following the concepts of the author and the chromosome numbers which are included are said to be based on Icelandic material. Both English and Icelandic common names are included. Separate indexes are given for the English, Icelandic and Latin names. There is no glossary of botanical terms but the author has deliberately tried to use non-technical descriptive language.

The work seems to be quite free of typographical errors, but three errors in the numbering of the line drawings were noted: the figure number for *Hierochloe odorata* in the text should read 119 rather than 112; the drawing for *Carex caryophyllea* (133a) is unnumbered; and the figure number for *Sagina saginoides* in the text should read 254 rather than 252.

This new flora of Iceland will be well received both by the casual visitor to Iceland and by the scientific community who may need to identify specimens from the island or wish to know the floristic components of that part of the circumpolar flora that occur there.

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Canadian Wildflowers Through the Seasons

By Mary Ferguson and Richard M. Saunders. 1982. Van Nostrand Reinhold, Toronto. 160 pp., illus. $29.95.

Canadian Wildflowers 1985

By Mary Ferguson. 1984. Key Porter Books, Toronto. 112 pp., illus. $9.95.

The first of these titles comprises a collection of 124 excellent color photographs of native and introduced plants found in various parts of Canada, each accompanied by a few paragraphs that tell some interesting facts about the plant, time of flowering, range, habitat, uses if any and derivation of the latin or scientific name. The book is divided into three sections, spring, summer and fall, each with a short introduction. Indexes are provided for English common names and scientific names. Credits are given to 17 photographers, most photographs were however, taken by Mary Ferguson. This book which measures 9¾ × 10 inches is essentially a "coffee-table" volume.

The second item is a ring-bound date book for 1985, 5¼ × 8½ inches. There is a 2-page introduction that deals mainly with photography. The bulk of the book is comprised of a left hand page with about one inch space for each of the seven days of the week with a short paragraph at the foot that gives the English common name, scientific name, habitat, time of flowering and fruiting, and range of the colorful flowers or fruits on the opposite page. The book is in an attractive box that carries the same picture of a purple violet that appears on the cover.

Both of these volumes would make attractive gifts to someone who has a love for wild flowers.

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ENVIRONMENT

The Great Lakes Forest: An Environmental and Social History

Edited by Susan L. Flader, 1983. University of Minnesota Press, Minneapolis. xxxii + 336 pp., illus.

For anyone familiar with the forests of central Ontario and the Great Lakes states, this book will provide a fascinating insight into the pressures and influences, both natural and anthropogenic, which come to bear on the vegetation of the area. In fact, the papers presented in this book are relevant to other forested regions of northeastern North America.

This book brings together information on all aspects of the forest environment and its use. The papers forming its chapters were originally presented at a symposium sponsored by the Forest History Society and the State Historical Society of Wisconsin, 6–8 June 1979. Part 1, consisting of four papers, deals with the forest ecosystem and impacts upon it brought about by the environmental factors such as fire, weather, and soils. An attempt is made to reconstruct the nature and origin of the forest before its removal by non-native settlers. Also discussed are some of the diverse impacts which man's activities have had on the natural environment of the region as a whole. The effects of forest removal on soil and water temperatures, erosion, and wildlife populations (including local extirpation events) are among the issues addressed. Interesting contrasts can be seen in the philosophies of the contributors to this book. For example, E.A. Bourdo, Jr., writing about 'The Forests the Settlers Saw', shows an obvious bias toward the perceived benefits of forest management. I suppose this is a matter of opinion, but it is certainly not mine. The paper by David M. Gates et al. on 'Wildlife in a Changing Environment', while dealing with recent pressures which have adversely impacted upon wildlife, goes overboard and sensationalizes when speculating on future impacts of forest-related industries.

The second part of the book relates the experiences of native peoples during the changes that took place in the Great Lakes Forest. The ability of the Menominee tribe to manage the forests on their Wisconsin reservation, on a sustained-yield basis, for productivity, aesthetics, and wildlife, in spite of state and federal governments, is particularly informative.

Part 3 deals with the institutional and social changes which took place in the Upper Great Lakes region from the mid-1800's to the present. The philosophies of settlers, lumbermen, and politicians are elaborated in these papers. When settlers first arrived in the region, their main objective was to clear the land for agriculture, and this goal was advocated by the politicians. Lumbermen did not think about long-term forest management in this context. As the forests were depleted, and as the inviability of extensive agriculture in the region became obvious, attitudes

changed, but it took lumbermen, and to some extent, politicians, quite a while to adjust their policies and practices. Also of considerable interest are the papers contrasting the Ontario situation with that of the Upper Great Lakes states. The amounts of public land held by Ontario were (and are) considerably larger.

The two papers in Part 4 attempt to summarize the present state of the Great Lakes Forest and to develop a scenario for its future use. One of these papers condones the concepts of intensive management, including planting with improved strains of trees, and developing monocultures. It contains an overtone of displeasure with the current trend to set aside some forest-lands for non-consumptive uses. Although multiple-use management concepts are invoked, it is unfortunate that these particular authors appear to place little or no value on protection of selected parcels of land.

The papers forming Part 5 (Perceptions and Values) are perhaps the most important part of this book. They serve to summarize the changes in the public attitude toward forests from the time Euro-Americans (and -Canadians!) set foot on the land until the present. While no reasonable person would suggest that logging should be discontinued in the Great Lakes Forest, the need for updated management concepts and policies is obvious. Foresters have fallen way behind in their understanding of the public perception of forests. It is time they realize that forests can be used for more than just cutting down trees.

A very few trivial production errors (typographical errors, etc.) were noted in the text, but these do not deter from the value of this book. This is a fascinating compendium of papers dealing with all of the issues relating to the Great Lakes Forest. Although some of the papers tend to be biased in one direction or the other, all sides of each issue are addressed somewhere in the body of the book. I highly recommend this book to teachers, ecologists, historians, forest industry employees, politicians, and all citizens interested in our forest resources.

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Voyage of The Iceberg

By Richard Brown. 1983. James Lorimer, Toronto. 152 pp. illus.

This book is natural history in the best sense of the term. It details a specific pattern in nature and brings together the separate strands to make up the final picture. The author traces The Iceberg (as he says, there has been only one The Iceberg in human history.) from its calving in Jakobshavn Fjord in West Greenland, through its travels north, around and back Baffin Bay, south in Davis Strait, along the coast of Labrador, into and out of Notre Dame Bay, Newfoundland, and across the Grand Banks to its fateful appointment with a certain ship called *Titanic*. Along its travels The Iceberg contacts or influences a host of creatures, from seals to copepods, from whales to whalermen, from dovekies to Inuit, from Captain Bernier to John Jacob Astor. The author skillfully weaves a series of fascinating stories that tie all these creatures together. He has done a superb job of research on the history and travels of a most unlikely collection of humans. The writing is clear, concise and flowing, with frequent brilliant descriptive phrases: ". . . elegant little kittiwakes, grey and white and yodelling" . . . "foxes and ptarmigan, too, white on white, with smears of bloody feathers to show where the foxes have won" . . . "The ice is fragile enough to begin with, turning to mush as soon as the sun touches it. Even the dovekies can swim through it, leaving tiny icebreaker tracks behind them."

I particularly appreciated the description of The Iceberg among the islands in Notre Dame Bay. I have a vivid memory of being bounced awake one night, while camped on Inspector Island, by a huge, pinnacled iceberg grounding on the opposite side of the island and shaking it to its very foundations.

I wish all Canadian history was presented in such a fascinating manner. Indeed, if Bio I were presented like this we would have a lot more future biologists and naturalists.

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Spruce Woods Provincial Park

By Manitoba Department of Natural Resources, Winnipeg. 1982. 32 pp., illus. $2.50.

"Spruce Woods Provincial Park exists as an island of exceptional natural beauty surrounded by a sea of crops, farms, and rural towns. Entering the area is rather like stepping back in time, for much of this land exists as it did hundreds of years ago."

This attractive 32-page booklet uses Jim Carson sketches and colour photographs to depict all seasons of the year in one of Manitoba's most interesting and most accessible provincial parks. For the visitor, it provides a brief account of the history, geology, anthropology, and natural history of the area. Ernest Thompson Seton and the Criddle family are recognized appropriately as early naturalists there.

Unfortunately, minor errors suggest that the text received less careful attention than did layout. Pemmican is pounded not powdered meat; in the 1800s both 'pine' and 'epinette' meant spruce, whereas 'cypres' meant jackpine; Seton's homestead was near the present site of Runnymede, Saskatchewan, not 'nearby to the Spruce Woods'; Seton did make an impression on Norman and Stuart Criddle, but they were only eight and five years of age at the time and this one visit can hardly be the reason they became "well known Canadian naturalists in their own right." My prejudice is that such errors are increasingly common in Government publications which list no author (Beth Follett and Betty Romanowski provided 'groundwork' and 'information') and which are inadequately refereed. These errors detract needlessly from an otherwise commendable publication.

Two maps would have been even more useful had they shown six additional locations mentioned in the text: Sewell, Treesbank, Pine Creek, Arthur Thompson's farm, Percy Criddle's farm, and Seton's bridge.

In spite of these quibbles, I recommend this most appealing publication to anyone remotely interested in the area. And the price is right.

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NEW TITLES

Zoology

Acoustic communication of birds: volume 1, production, perception, and design features of sound and volume 2, song learning and its consequences. 1982. Edited by Donald E. Kroodsma and Edward H. Miller. Taxonomic editor Henri Ouellet. Academic Press, New York. xxxii + 372 pp., illus, and xxxii + 390 pp., illus. U.S. $36 and U.S. $39.

Alaska's salmon fisheries. 1983. Edited by Jim Rearden. Alaska Geographic volume 10, number 3. Alaska Northwest, Anchorage. 130 pp., illus. U.S. $15.50.

***The American darters.** 1984. By Robert A. Kuehne and Roger W. Barbour. University of Kentucky Press, Lexington. 216 pp., illus. U.S. $45.

***Amphibians and reptiles of New England: habitats and natural history.** 1983. By Richard M. DeGraaff and Deborah D. Rudis. University of Massachusetts Press, Amherst. 85 pp., illus. Cloth U.S. $14; Paper U.S. $6.95.

†**The amphipod superfamily Corophioidea in the northeastern Pacific region: 3. Family Isaeidae: Systemics and distribution ecology.** 1983. By K. E. Conlan. Publications in Natural Sciences, 4. National Museum of Natural Sciences, Ottawa. viii + 75 pp., illus. Free.

Animal behaviour: ecology and evolution. 1983. By C. J. Barnard. Croom, Helm, London. 340 pp., illus. Cloth £17.95; paper £8.95.

†**The archaeology of beekeeping.** 1984. By Eva Crane. Cornell University Press, Ithaca, New York. 360 pp., illus. U.S. $35.

The Australian crickets (Orthoptera: Gryllidae). 1983. By Daniel Otte and Richard D. Alexander. Academy of Natural Sciences of Philadelphia, Philadelphia. vi + 478 pp., illus. U.S. $45.

The badgers of the world. 1983. Edited by Charles A. Long and Carl Arthur Killingley. Thomas, Springfield, Illinois. xxiv + 404 pp., illus. U.S. $39.75.

†**Bibliographia invertebratorum aquaticorum Canadensium: volume 1, index generum and volume 2, index bibliographicus.** 1983. By Diana R. Laubitz, Ian Sutherland and Nishi Sharma. National Museum of National Sciences, Ottawa. 57 pp. and 244 pp. Free.

***Bibliography of the genera *Caladris* and *Limicola*.** 1983. By Sven Blomquist. Volume 3. Ottenby Bird Observatory, Dergerhamn, Sweden. 1364 references. U.S. $7.

***Bibliography of the genus *Phalaropus*.** 1983. By Sven Blomquist. Volume 4. Ottenby Bird Conservatory, Degerhamn, Sweden. 394 references. U.S. $4.

***The birds of British Columbia: Sparrows and Finches.** 1983. By C. J. Guiguet. British Columbia Provincial Museum, Victoria. Handbook 42. 122 pp., illus. $2.

Birds of the world. 1961, 1983. By Oliver Austin jr. Reprint edition. Golden Press, Racine, Wisconsin. 320 pp., illus. U.S. $25.

***Their blood runs cold: adventures with reptiles and amphibians.** 1983. By Whit Gibbons. University of Alabama Press, University. xv + 164 pp., illus. Cloth U.S. $19.75; paper U.S. $9.95 plus U.S. $1 postage.

***Caribbean fish life: index to the local and scientific names of marine fishes and fishlike invertebrates of the Caribbean area (tropical western central Atlantic Ocean).** 1983. By Jacques S. Zaneveld. Brill, Leiden, Netherlands. xviii + 163 pp + map. D. Gld. 56.

***A catalogue of chironomid genera and subgenera of the world including synonyms (Diptera: Chironomidae).** 1983. By Patrick Ashe. Entomologica Scandinavica Supplement No. 17. Swedish Research Councils, Stockholm. 68 pp. U.S. $15 plus postage.

†**A checklist and bibliography of Sipuncula from Canadian and adjacent waters.** 1983. By P. G. Frank. Syllogeus No. 46. National Museum of Natural Sciences, Ottawa. 47 pp., illus. Free.

***Chironomidae of the holarctic region: keys and diagnoses, part 1: larvae.** 1983. Edited by Torgny Wiederholm. Entomologica Scandinavica Supplement No. 19. Swedish Research Councils, Stockholm. 457 pp., illus. U.S. $73 plus postage.

†**Communication and behaviour of whales.** 1984. Edited by Roger Payne. AAAS Selected Symposium 76. Westview Press, Boulder, Colorado. xii + 643 pp., illus. U.S. $35.

Conserving sea turtles. 1983. By Nicholas Mrosovsky. Zoological Society of London, London. vii + 176 pp., illus. U.S. $10.

Current ornithology, volume 1. 1983. Edited by Richard F. Johnston. Plenum, New York. xvi + 425 pp., illus. U.S. $39.50.

†**Darwin's finches.** 1983. By David Lack. Cambridge University Press, New York. iii + 208 pp. + plates, illus. Cloth U.S. $39.50; paper U.S. $13.95.

Deer biology, habitat requirements, and management in western North America. 1981. Edited by Peter F. Ffolliot and Sonia Gallina. Instituto de Ecologia, Mexico City. 240 pp., illus. U.S. $30.

†**The ecological web and the distribution and abundance of animals.** 1984. By H. G. Andrewartha and L. G. Birch. University of Chicago Press, Chicago. c560 pp., illus. cU.S. $35.

A field guide to dangerous animals of North America. 1983. By Charles K. Levy. Stephen Greene Press, Battleboro, Vermont. xii +164 pp., illus. U.S. $9.95.

Freshwater wilderness: Yellowstone fishes and their world. 1983. By John D. Varley and Paul Schullery. Yellowstone Library and Museum Association, Yellowstone National Park. iv + 134 pp. Cloth U.S. $19.95; paper U.S. $12.95.

***Glossary of chironomid morphology terminology (Diptera: Chironomidae).** 1980. By Ole A. Saether. Entomologica Scandinavica Supplement No. 14. Swedish Research Councils, Stockholm. 51 pp., illus. 75 Sw. Kr.; U.S. $13.60 plus postage.

Illustrated facts and records book of animals. 1983. By Theodore Rowland-Entwistle. Arco, New York. 236 pp., illus. U.S. $9.95.

†**The importance of wildlife to Canadians: highlights of the 1981 national survey.** 1983. By Fern L. Filion, Stephon W. James, Jean-Luc Ducharme, Wayne Pepper, Roger Reid, Peter Boxall, and Dan Teillet. Canadian Wildlife Service, Ottawa. 40 pp., illus. Free.

Intenstive regulation of duck hunting in North America: its purposes and achievements. 1983. By Hugh Boyd. Occasional Paper Number 50. Canadian Wildlife Service, Ottawa. 244 pp., illus. Free.

***Kirtland's Warbler: the natural history of endangered species.** 1983. By Lawrence H. Walkinshaw. Cranbrook Institute of Science, Bloomfield Hills, Michigan. xii + 207 pp., illus. U.S. $11.95.

Michigan mammals. 1983. By Rollin H. Baker. Michigan State University, East Lansing. xxii + 642 pp., illus. U.S. $60.

†**The mosquitoes of British Columbia.** 1983. By Peter Belton. Handbook 41. British Columbia Provincial Museum, Victoria. 189 pp., illus. $5.

†**Les oiseaux de St.-Pierre et Miquelon.** Pas de date. Par Roger Etcheberry. R. Etcheberry, C. P. 328, Saint-Pierre. 78 pp., illus. $3.

Pigeons and doves of the world. 1983. Byi Derek Goodwin. Third edition. Cornell University Press, Ithaca. 496 pp., illus. U.S. $48.50.

Plankton and productivity in the oceans: volume 2-zooplanton. 1983. By J. E. G. Raymont. Second edition. Pergamon Press, Elmsford, New York. 700 pp., illus. Cloth cU.S. $86.50; paper cU.S. $21.90.

*****Proceedings of the second international conference on the study and conservation of the migratory birds of the Baltic Basin.** 1980. Acta Ornithologica. Polska Akademia Nauk, Gdansk. 193 pp. no price given.

†**The pygmy smelt, *Osmerus spectrum* Cope, 1870, a forgotten sibling species of eastern North American fish.** 1983. By Jacqueline Lanteigne and Don E. McAllister. Syllogeus No. 45. National Museum of Natural Sciences, Ottawa. 32 pp., illus. Free.

*****A review of the genera *Doithrix* n. gen., *Georthocladius Strenzke, Parachaetocladius* Wülker, and *Pseudorthocladius* Goetghebuer (Diptera: Chironomidae, Orthocladiinae).** 1983. By Ole A. Saether and James E. Sublette. Entomologica Scandinavica Supplement No. 20. Swedish Research Councils, Stockholm. 100 pp., illus. U.S. $19 plus postage.

The successful dragons: a natural history of extinct reptiles. 1983. By Christopher McGowan. Samuel Stevens, Toronto. viii + 264 pp. no price given.

†**The systematics and distributional ecology of the superfamily Ampeliscoidea (Amphipoda: Gammaridea) in northeastern Pacific region. II. The genera *Byblis* and *Haploops*.** 1983. By John J. Dickinson. Publication in Natural Sciences, 1. National Museum of Natural Sciences, Ottawa. vi + 38 pp., illus. Free.

†**Under Alaskan seas: the shallow water marine invertebrates.** 1984. By Nancy and Lou Barr. Alaska Northwest, Edmonds, Washington. 210 pp., illus. U.S. $14.95.

Wildfowl of Britain and Europe. 1982. By Malcolm Ogilvie. Oxford University Press, New York. vii + 84 pp., illus. U.S. $16.95.

Wildlife feeding and nutrition. 1983. By Charles T. Robbins. Academic Press, New York. xvi + 344 pp., illus. U.S. $31.50.

Botany

The biology of nectaries. 1983. Edited by Barbara Bentley and Thomas Elias. Columbia University Press, New York. x+ 260 pp., illus. U.S. $33.50.

Field guide to the orchids of North America: from Alaska, Greenland, and the Arctic south to the Mexican border. 1983. By John G. and Andrew E. Williams. Universe, New York. 143 pp., illus. U.S. $10.95.

*****A field guide to the sedges of the Cariboo Forest Region, British Columbia.** 1983. By Anna Roberts. Land Management Report 14. British Columbia Ministry of Forest, Victoria. 89 pp., illus. Free.

*****Flora of Alberta.** 1983. By E. H. Moss. Second edition, revised by John G. Parker. University of Toronto Press, Toronto. 687 pp. + maps. $45.

The growth and functioning of leaves. 1983. Edited by J. E. Dale and F. L. Milthorpe. Cambridge University Press, New York. xvi + 540 pp., illus. U.S. $89.50.

*****Icelandic flora.** 1983. By A. Love. Alemenna Bokafelagid, Reykjavik, Iceland. 403 pp., illus. $20.

Notes on the vascular plants of the Mackenzie Mountain barrens and surrounding area. 1982. By Hilah Simmons and Sam Miller. Northwest Territories Renewable Resources Branch, Yellowknife. xi + 132 pp. Free.

*****Wildflowers of the Yukon and northwestern Canada including adjacent Alaska.** 1983. By John C. Trelawny. Gray's Publishing, Sidney, British Columbia. 213 pp., illus. $19.95.

Environment

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Cover: Migrating Sandhill Cranes, *Grus canadensis*, photographed 17 September 1977 at Delta Junction, Alaska, by Brina Kessel. See article by Kessel pp. 279–292.

The Canadian Field-Naturalist

Volume 98, Number 3 July-September 1984

Migration of Sandhill Cranes, *Grus canadensis*, in East-central Alaska, with Routes through Alaska and Western Canada

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One hundred fifty thousand to 200 000 Sandhill Cranes migrate through the upper Tanana River Valley of eastern Alaska, primarily from the last week of August to the first week of October and from the last week of April to the middle of May. These cranes summer throughout most of interior and western Alaska and in northeastern Siberia, and they winter mostly in eastern New Mexico-western Texas and adjacent northern Mexico. During the peak of migration, 10 000 to 50 000 cranes may pass through the upper Tanana region in a single day. Except for periods of bad weather, ground use is primarily for overnight roosting and feeding. Open areas are selected for roost sites, with a preference shown for alluvial islands of wide, braided riverbeds. Timing and specific routes are affected by weather, especially strong winds and poor visibility. Cranes are primarily daylight, fair-weather migrants, but sometimes migrate at night and during inclement weather. Most migration occurs between 300 and 900 m AGL, with flights higher in spring than fall.

Key Words: Sandhill Crane, *Grus canadensis*, Alaska, migration

The occurrence of a major fall and spring movement of Sandhill Cranes (*Grus canadensis*) through the upper Tanana River Valley in east-central Alaska has been common local knowledge for many years. It was probably first recorded by Alaskan naturalist Olaus J. Murie when, on 8 May 1921 at Tanacross, Alaska, he wrote in his journal, "Flock after flock came over, noisily. For a time I could look anywhere out over the Tanana Valley with the glasses and see one or more flocks at varying distances, appearing like swarms of mosquitoes. . . . I estimated that fully 10 000 to 15 000 cranes passed over within my view this morning." (Murie 1979: 31). Other than the fact of its existence, however, little was known about this spectacular passage until the current study, which was conducted from fall 1976 to spring 1979. We now know that approximately half of the world's population of the Lesser Sandhill Crane (*G. c. canadensis*) passes through the upper Tanana River Valley during a 2- to 3-week period each fall and spring. At Delta Junction (64°02′N, 145°44′W), their migratory pathway is briefly constricted to a width of 30-40 km, and near Lake George (63°47′N, 144°31′W) in spring to possibly only 16 km.

Study Area

The main study area extended from the Delta River (approx. 145°50′W) to the Alaska-Canada border (141°00′W), a distance of approximately 250 km; and from Mt. Fairplay (63°40′N, 142°13′W) and the Ladue River where it crosses the Alaska-Canada border (63°16′N) on the north to the Tanana River on the south (see below). This area consisted of about 1200 km^2 and included the flats and lowlands of the upper valley of the Tanana River and, to the north, the upland hills of the Tanana-Yukon Highlands. It was a typical taiga mosaic of forested and treeless habitats, with about 150 km^2 of agricultural lands at Delta Junction, which included pastures, hayfields, and some 12 km^2 of grain crops, primarily barley (*Hordeum vulgare*). Except for the Alaska Highway, the Taylor Highway, and local roads in the vicinity of Delta Junction, this vast area was essentially devoid of roads.

Methods

Two field crews were stationed in the study area during migration, one (one to two observers) within the relatively constricted portion of the migratory pathway at Delta Junction and the other (one to three observers) 175 km farther east. The Delta Junction crew used three main observation sites, which commanded extensive views of the migratory routes, and obtained as complete a count as possible of the cranes passing through the region. The other crew, responsible for determining the migratory pathways, used sev-

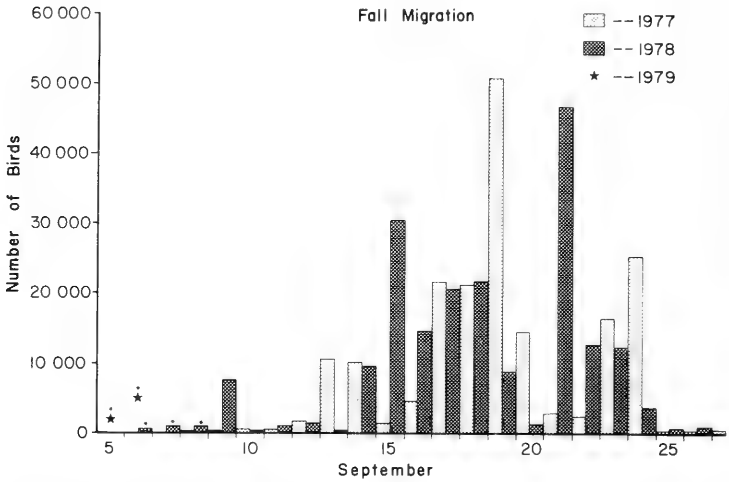

FIGURE 1. Daily counts of Sandhill Cranes during fall migration, upper Tanana River Valley, Alaska. Dots (•) indicate partial counts made outside of the main count periods.

eral automobiles to make daily searches for migrating cranes, primarily from Tetlin Junction to Mt. Fairplay and from Tanacross to Northway. When flocks of cranes were found, counts were made to ascertain the relative intensity of use of different routes. In addition, this crew used small fixed-winged aircraft on occasion to search for and follow migrating flocks and to search for roosting sites.

Aircraft proved particularly useful for delineating migratory routes when observers could get airborne during heavy flights. Likewise, information on roosting sites was most effectively obtained from early morning flights following a heavy passage late on the preceding day. Unless we knew that a major passage was underway, hunting for migratory flocks by aircraft was ineffective.

Field observations were conducted throughout the main fall and spring migration periods, and observers attempted to remain at observation posts and in the field throughout the daily period of crane activity. Thus, on some days observations began prior to 0400 Alaska Standard Time (AST) or ended after 1900, or even 2100 AST.

Data recorded for each crane observation were date, locality, number of birds, time of day, flight height and direction, wind direction and velocity, height and percent of cloud cover, and descriptions of any ground utilization or reaction to disturbance. Hourly weather reports for Delta Junction and Northway were obtained from the U.S. National Weather Service. These reports included height and characteristics of lowest clouds, height of cloud ceiling, total opaque sky cover, horizontal visibility, type of obstruction to visibility (fog, snow, rain), wind speed and direction, and barometric pressure.

The crane field data from the stationary observation posts at Delta and the weather data from Delta and Northway were divided into time periods: 0500-1000, 1001-1500, 1501-2100, and 2101-0459 AST. All crane and weather data were combined and summarized for these four daily periods for every day of each spring and fall migratory period.

Dates and Size of Movement

The first signs of fall premigratory staging in central Alaska can be detected during the first week of August, apparently the gathering of non- and failed breeders; flocking and at least local movements become more evident after 10 August and increase throughout August (Kessel unpublished data). The main migratory movement begins during the last week of August, but most migration occurs during September; a few stragglers continue to move through central Alaska as late as mid-October (ibid.).

There is a major exodus of local cranes from the Tanana River Valley during the last week of August and the first week of September. Similarly, the main passage southward up the Yukon River from the Yukon Flats occurs during this period (Kessel unpublished data). In most years, however, significant numbers of migrants do not occur in the upper Tanana River Valley until about 5 September, and

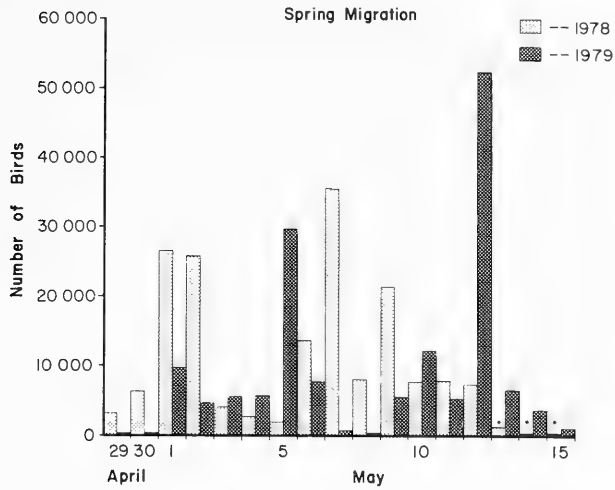

FIGURE 2. Daily counts of Sandhill Cranes during spring migration, upper Tanana River Valley, Alaska. Dots (●) indicate partial counts made outside of the main count periods.

some years not until almost a week later. These passage birds apparently are from breeding grounds in western Alaska and northeastern Siberia. During fall migration 1977 and 1978, large numbers of cranes passed through the upper Tanana River Valley from 13 to 24 September (Figure 1). Although weather conditions cause considerable variation in the daily count, on any single day during this 11-day period 10 000 to 50 000 cranes may move through the region. Maximum daily counts occurred on 19 September 1977 (51 000 cranes) and 21 September 1978 (47 000 cranes).

In spring, occasional cranes may reach central Alaska as early as 15 April, but usual earliest arrivals occur 20-22 April (Kessel unpublished data). With some variability due to weather, significant numbers do not occur in the upper Tanana River Valley until the last day or two of April. During 1978 and 1979, large numbers passed through Delta Junction from 1 to 12 May (Figure 2), with maximum daily counts occurring on 7 May 1978 (35 000 cranes) and 12 May 1979 (52 000 cranes).

Total crane counts during fall migration at Delta Junction were 186 000 in 1977 and 198 000 in 1978. In spring, 172 000 cranes were counted in 1978 and 148 000 in 1979. These numbers are minimums, since they were only of birds actually seen. Some birds passed through the region before and after the main count periods, a small but unknown number migrated after dark or in fog, and a few flocks apparently slipped unobserved past the field crews. It is doubtful, however, that as many as 10% of the migrants were missed.

Flocks of migrating cranes are not easy to count (see Figure 3), and the level of counting error and differences in such errors among the observers are unknown. Hence, it is not known whether or not the variation in total numbers counted between years or between seasons is significant. The lower numbers in spring compared to fall would be expected, in view of the addition of young birds after the breeding season and losses due to hunting and natural mortality during migration and winter.

Migration Routes

Upper Tanana River Valley

Migrating cranes in fall 1977 and 1978 usually entered the upper Tanana River Valley between Donnelly Dome (63°47′N, 145°47′W) and a point about 7 km north of Delta Junction, a corridor 30-40 km wide. They then crossed the Tanana River and passed into the southern edge of the Tanana-Yukon Highlands (Figure 4). After traversing these highlands and crossing the Taylor Highway, mostly south of Mt. Fairplay between Mileposts 14 and 29, the cranes descended into Yukon Territory, usually south of the confluence of the Ladue and White rivers. After crossing the White River, the birds flew toward the mouth of the Pelly River.

Winds, especially quartering tail winds, caused sev-

eral consistent variations in the fall migration routes through the region, resulting in a north-south variation of up to 70 km (Figure 4). If winds at Northway were northwesterly, crane flocks, instead of entering the Tanana-Yukon Highlands, followed the course of the Tanana River ESE, taking shortcuts across major bends. Sometimes they then crossed the south end of the Taylor Highway and passed over the hills north of the Tanana River, but at other times they continued up the Tanana River, where, at various points between Northway and the Alaska-Canada border, they cut eastward toward the White River. During the September movements of 1977 and 1978, about a third of the days had wind-induced shifts to the Tanana River Valley.

Southwest winds caused birds to cross the Taylor Highway farther north than otherwise, e.g., on 14 September 1978 they crossed at Milepost 35, north of Mt. Fairplay (Figure 4). Strong SE winds (average 20-30 km/h) at Delta Junction, which occurred on seven days during 1977 and 1978, caused migrating flocks to enter the region up to 6 km farther north than usual.

In spring, the main pathway through the upper Tanana River Valley was more constricted and farther south than in fall (Figure 5), being similar to the Tanana River Valley route followed in fall under conditions of NW winds (cf. Figures 4 and 5). Winds caused some route variations in spring, but their effects were not as frequent nor as great as in fall. ENE winds near the Alaska-Canada border, even if only 10-15 km/h, caused the cranes to shift from their usual WNW direction to a more westerly direction, which brought them onto the Tanana River farther east than under other conditions (Figure 5). That phenomenon was particularly evident during the afternoon of 3 May 1979, and, on the morning of 4 May, cranes were seen leaving roosts as far south as Tetlin Lake and were seen crossing the highway 25 km south of Tok. In the Delta Junction area, strong winds (20-30 km/h) from either the SW or SE caused migrants to shift their route from the south side of the valley, where they were relatively close to the Alaska Range, toward the north edge of the valley.

Alaska and Western Canada

The spectacular crane passage through the upper Tanana River Valley is composed of birds that summer throughout interior Alaska west of the Tanana-Yukon Highlands, throughout coastal western Alaska from the Yukon-Kuskokwim Delta to Kotzebue Sound, and in northeastern Siberia and that migrate via the Central Flyway to their main wintering areas in eastern New Mexico-western Texas and adjacent northern Mexico. Evidence, cited below, consists of sighting reports of major aggregations and movements, sightings of color-marked birds, and banding recoveries.

WESTERN ALASKA: The Central Flyway population appears to form two main groups in western Alaska, one that migrates to summering grounds in the Yukon-Kuskokwim Delta, Nunivak Island, and rarely to St. Matthew Island in the central Bering Sea, and the other that migrates through the Norton Sound-southern Seward Peninsula region to summering grounds on the Seward Peninsula, St. Lawrence Island in the northern Bering Sea, and northeastern Siberia (Figure 6). Confirmation that both of these groups are from the Central Flyway comes from banding recoveries and resightings of birds color-marked on wintering grounds in eastern New Mexico-western Texas and on the major staging area of the North Platte and Platte rivers, Nebraska. In addition to many sightings at Delta Junction, including during this study, marked birds have been found in northeastern Siberia (mainly the lower Anadyr River drainage), on the Yukon-Kuskokwim River Delta, at the northeast edge of Norton Sound, and at Wales (Huey 1965; Wheeler and Lewis 1972; U.S. Bird-Banding Office; P. A. Vohs, Oklahoma Cooperative Wildlife Research Unit, personal communication). Likewise, birds marked in summer on the Yukon-Kuskokwim River Delta near Old Chevak have been found subsequently in southwestern and southcentral Saskatchewan, at the Platte River spring staging area, and in eastern New Mexico-western Texas and adjacent northern Mexico in winter (Boise 1979).

Another group of Sandhill Cranes summers in southwestern Alaska, along Bristol Bay and the Alaska Peninsula and in southcoastal Alaska, but this population remains south of the Alaska Range and migrates and winters in the Pacific Flyway (Herter 1982; T. Pogson, personal communication).

The passage of large numbers of cranes across the Bering Strait in both spring and fall has been witnessed by many observers (Bean 1882; Bernard 1923; Jaques 1929; Bailey 1943; Kessel and Gibson 1974 unpublished report, Portenko 1981, references below). The main movement usually occurs between 10 and 23 May (Kenyon and Brooks 1960; Breckenridge and Cline 1967; Flock 1972; Flock and Hubbard 1979) and between 5 and 20 September, peaking 13-19 September (Drury 1976; Shields and Peyton 1979; Woodby and Divoky 1983; Kessel and Gibson unpublished records). Movements in late August and during the first few days of September appear to be either staging movements or the exodus of local summering populations. These Bering Strait birds traverse the southern half of the Seward Peninsula, with weather probably determining whether the flights are coastal or inland (Alaska Department of Fish & Game

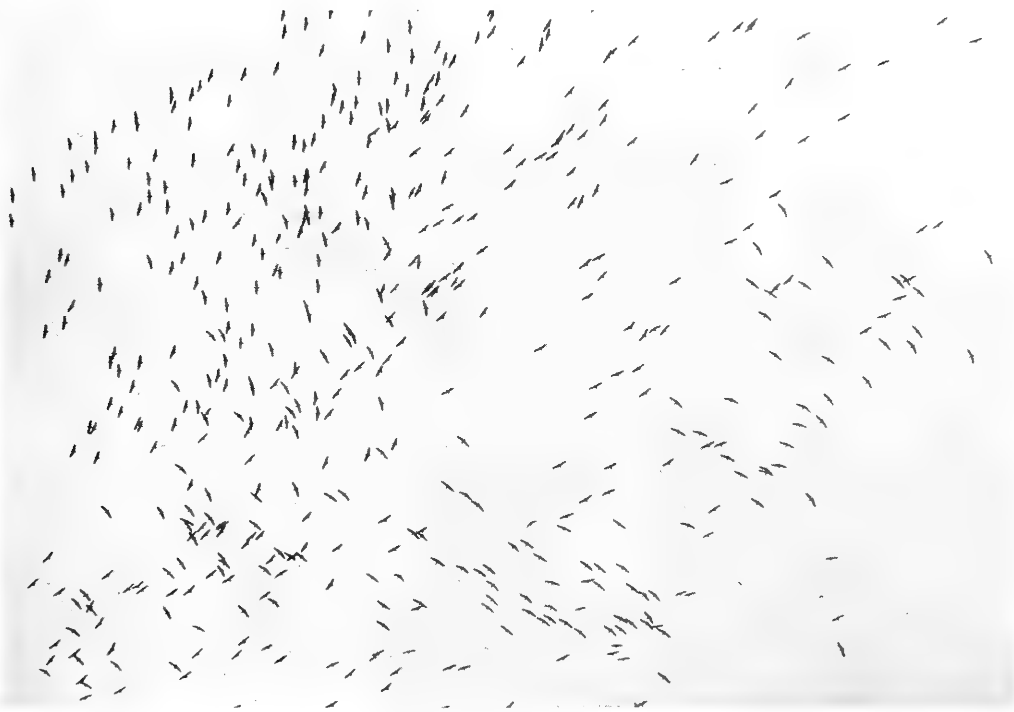

FIGURE 3. Migrating Sandhill Cranes, Delta Junction, Alaska, 7 May 1978.

unpublished notes; K. A. Child and P. C. Lent personal communication; Flock 1972; Drury 1976; Shields and Peyton 1979; Woodby and Divoky 1983; Kessel unpublished manuscript).

Emerging evidence suggests a much broader movement between Alaska and Siberia than described above, with birds flying farther south across Norton Sound and the northern Bering Sea. Such a route is plausible for several reasons: 1) Cape Chukotskiy, at the southeast tip of the Chukotsk Peninsula, and the Anadyr River estuary are on almost the same compass heading used by many flocks crossing western interior Alaska, 2) historically, this portion of the Bering Sea was part of the Pleistocene Bering Land Bridge (Hopkins 1967), and crane migration between the two continents probably evolved over that connection, 3) spring migration occurs during May, when the northern Bering Sea is still largely ice-covered, and 4) the distance from the head of Norton Sound to Cape Chukotskiy is about 540 km, a distance that can be traversed by cranes in a single day's flight under favorable weather conditions (Toepler and Crete 1979; Melvin and Temple 1982). Observational data corroborate this hypothesis: 1) A major movement of cranes, observed on radar on 11 May 1970, passed W-WNW over the Bering Sea south of Wales, in the vicinity of King Island, apparently making a direct flight from about Cape Rodney, at the southwest edge of the Seward Peninsula, to Mechigmenskii Bay on the Chukotsk Peninsula (Flock 1972), a distance over the pack ice of about 275 km; 2) small numbers of cranes have been reported in spring near Gambell, St. Lawrence Island, crossing the strait and heading northwest toward Cape Chukotskiy (Fay and Cade 1959; Johnson 1976), and local residents regularly see many small flocks (up to several 100 birds) flying across the strait and along both the north and south coasts of St. Lawrence Island during both spring and fall migration, arriving from the east in spring and the west in fall (P. Gologergen personal communication); and 3) the vicinity of Stuart Island and the wetlands near Stebbins at the southeast edge of Norton Sound is a major gathering area for cranes both spring and fall (Woodby and Divoky 1983) and may be an important departure and arrival site for cross-Bering Sea migrants. Unfortunately, except on St. Lawrence Island, which is somewhat south of the direct-line route, there are few observers.

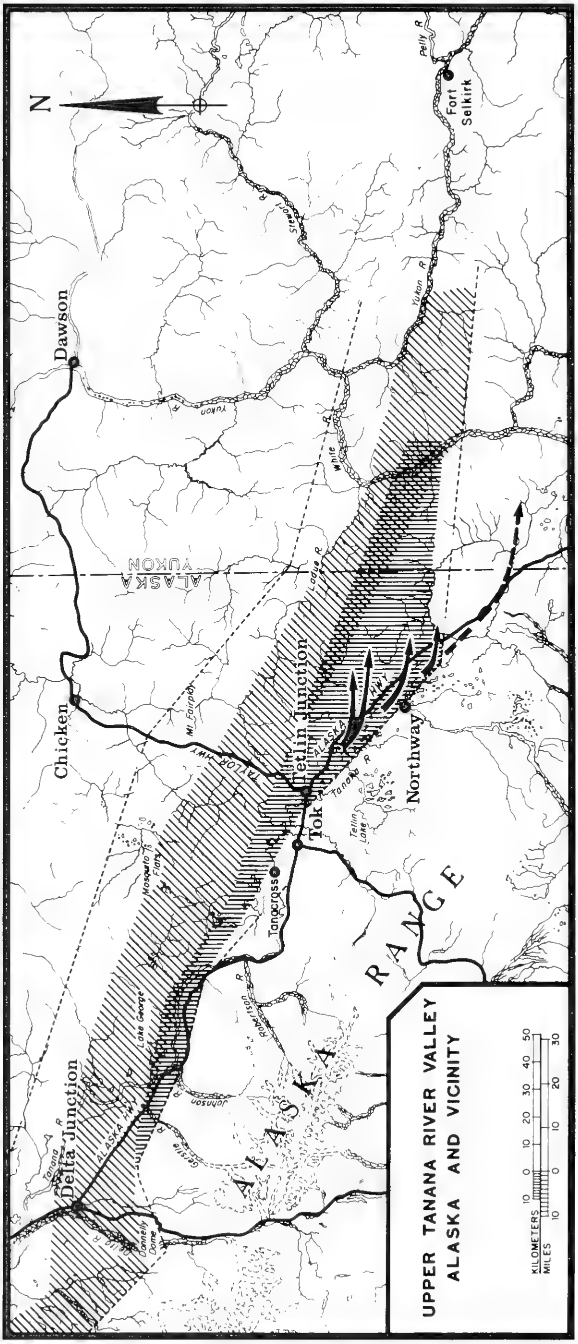

FIGURE 4. Fall migration pathway of Sandhill Cranes through the upper Tanana River Valley, Alaska.

Concentration of migrants.

Concentration of migrants when winds from the northwest.

---- Outline of migration pathway.

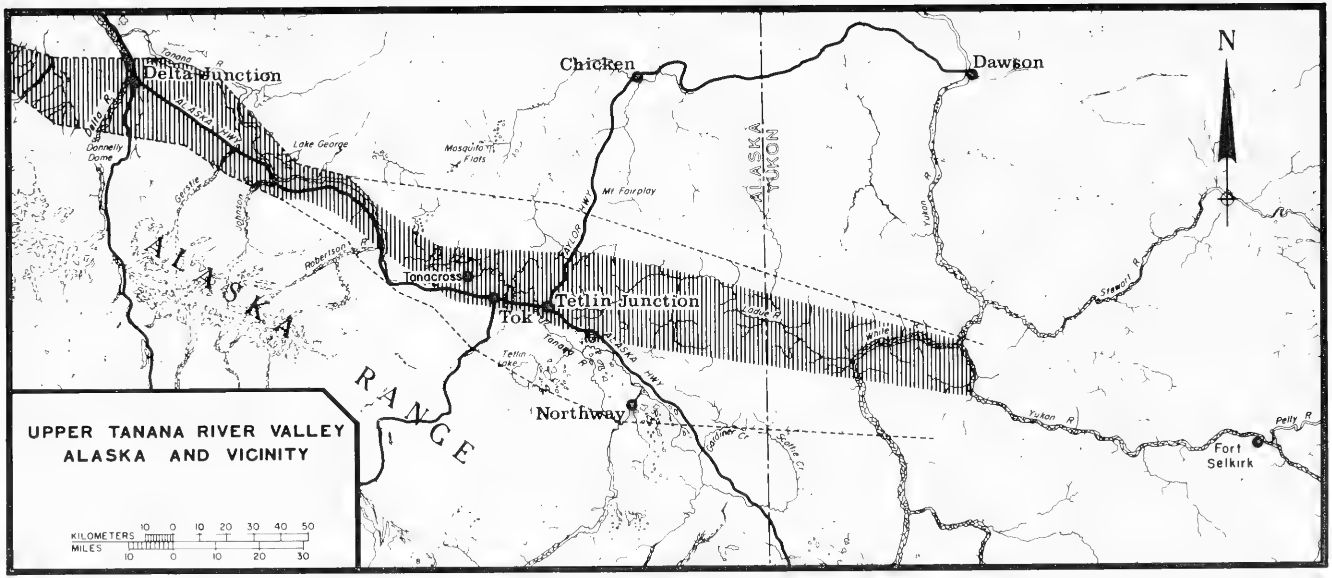

FIGURE 5. Spring migration pathway of Sandhill Cranes through the upper Tanana River Valley, Alaska.
Concentration of migrants.
---- Outline of migration pathway.

Migrant flocks from the Seward Peninsula-northern Bering Sea region fly inland from Norton Sound. At the northeast edge of the Sound, more than 20 000 cranes moved eastward during mid-September 1977 (L. J. Peyton personal communication). These birds apparently pass over Nulato (Helmericks 1944; Herter 1982) and then are joined by birds moving down the Koyukuk River drainage (T. O. Osborne personal communication), presumably from the Kotzebue Sound area. Farther south, a major movement passed eastward along the coast 28 km east of Stebbins between 16 and 20 September 1976 (L. Wheeler personal communication). All these flocks tend to coalesce as they move in a generally ESE direction over the low hills of western interior Alaska, until they are deflected to a more ENE direction by the Alaska Range (Figure 6). There have been few reports of this movement through the vast, sparsely-populated interior region, except near McGrath in spring and fall and at Lake Minchumina in fall (Kessel unpublished records). After reaching the Alaska Range, the cranes move along its north face, crossing over the northernmost "elbow" of the range near Healy (Kessel unpublished records) and flying eastward to the Delta Junction area.

Cranes of the more southern group — primarily from the Yukon-Kuskokwim Delta, where over half of Alaska's cranes spend the summer (estimated 77 000 birds: Conant et al. *in press*) — stage locally and depart on migration mostly between 8 and 20 September (Yukon Delta National Wildlife Refuge unpublished data). Flocks apparently leave the Delta in an E or NE direction and cross the low Kuskokwim Mountain Range, where "many hundreds" have been reported flying over Stony River and Sleetmute in both fall and spring, sometimes landing and feeding on berries on the ridges (P. Bobby personal communication). These birds merge with the northern group of migrants as they pass along the north face of the Alaska Range (Figure 6).

CENTRAL ALASKA: There are two known premigratory staging areas in central interior Alaska, where more than 1 000 cranes have been reported in fall (Kessel unpublished records): Minto Flats, and the Fish Lake area near Tanana. Cranes migrate from these areas in a generally southeast direction, joining the flights from western Alaska east of Healy (Figure 6).

EASTERN ALASKA-YUKON TERRITORY: The main migratory pathway through Yukon Territory is via the Pelly and Macmillan river valleys (Figure 7). Flight lines of cranes leaving the upper Tanana study area in 1977 and 1978 were followed by aircraft to the Yukon River, and the cranes continued eastward toward the confluence of the Yukon and Pelly rivers. Major flights of cranes have been reported along the Yukon River near Fort Selkirk (F. Weber personal communication), at Pelly Crossing (J. Whittley and P. Whitfield personal communication), where the Canol Road crosses the Pelly River and in the lower Ross River Valley (Rand 1946; Grünberg 1978; several interviewees this study), and in the Frances Lake area (Rand 1946). Large flocks have also been reported along the Alaska Highway in the vicinity of Watson Lake, Y.T., but there is a virtual absence of such reports along the highway farther west until it reaches the upper Tanana River study area (Kessel unpublished records; interviewees this study).

Wind directions may cause local variations in the flight path, and in fall 1978 and 1982 many cranes were observed migrating near Carmacks (J. Lammers in litt., C. Hyde personal communication). Northwest winds may have caused this southward displacement of birds, and it seems possible that cranes flying the Tanana River Valley route under the influence of such winds might continue to the Pelly River Valley in a line that would bring them over the vicinity of Carmacks.

The summering cranes from Alaska's Yukon Flats, an estimated 8 000 birds (Conant et al. *in press*), migrate southeast in fall up the Yukon River, past Circle, Nation, and Eagle (Kessel unpublished records). Although their movement precedes that of the major passage from western Alaska and Siberia, they fly the same route through Yukon Territory.

WESTERN CENTRAL FLYWAY: Flocks of migrating cranes have been observed flying in the vicinity of the Alaska Highway between Watson Lake, Y.T., and Fort Nelson, B.C. (S. R. Johnson, unpublished notes); and the Alaska-Siberia birds probably join with the Mackenzie River birds in the Peace River area of northwestern Alberta, where numbers of cranes are known to gather and feed (Stephen 1967; Lewis 1977) (Figure 7). From there, based on banding returns of Alaska-banded cranes (Boise 1979, U.S. Bird-Banding Office) and on the fact that numbers peak in late September (Stephen 1967), it appears that the Alaska cranes move to the staging area of southeastern Alberta-southcentral Saskatchewan. Peak fall populations farther east at the Last Mountain-Quill Lakes staging area occur in late August or early September (Stephen 1967), whereas the big flights of Alaska-Siberia cranes pass the upper Tanana River Valley area 13-24 September and would arrive in southern Alberta-Saskatchewan about nine days later (2 400 km divided by a mean daily flight distance of 267 km, as calculated by Melvin and Temple 1982). Again, judging from migration dates of *G. c. canadensis* (Buller 1967), it appears that the majority of Alaska birds in fall move south along the eastern face of the Rocky Mountains — through eastern Montana, east-

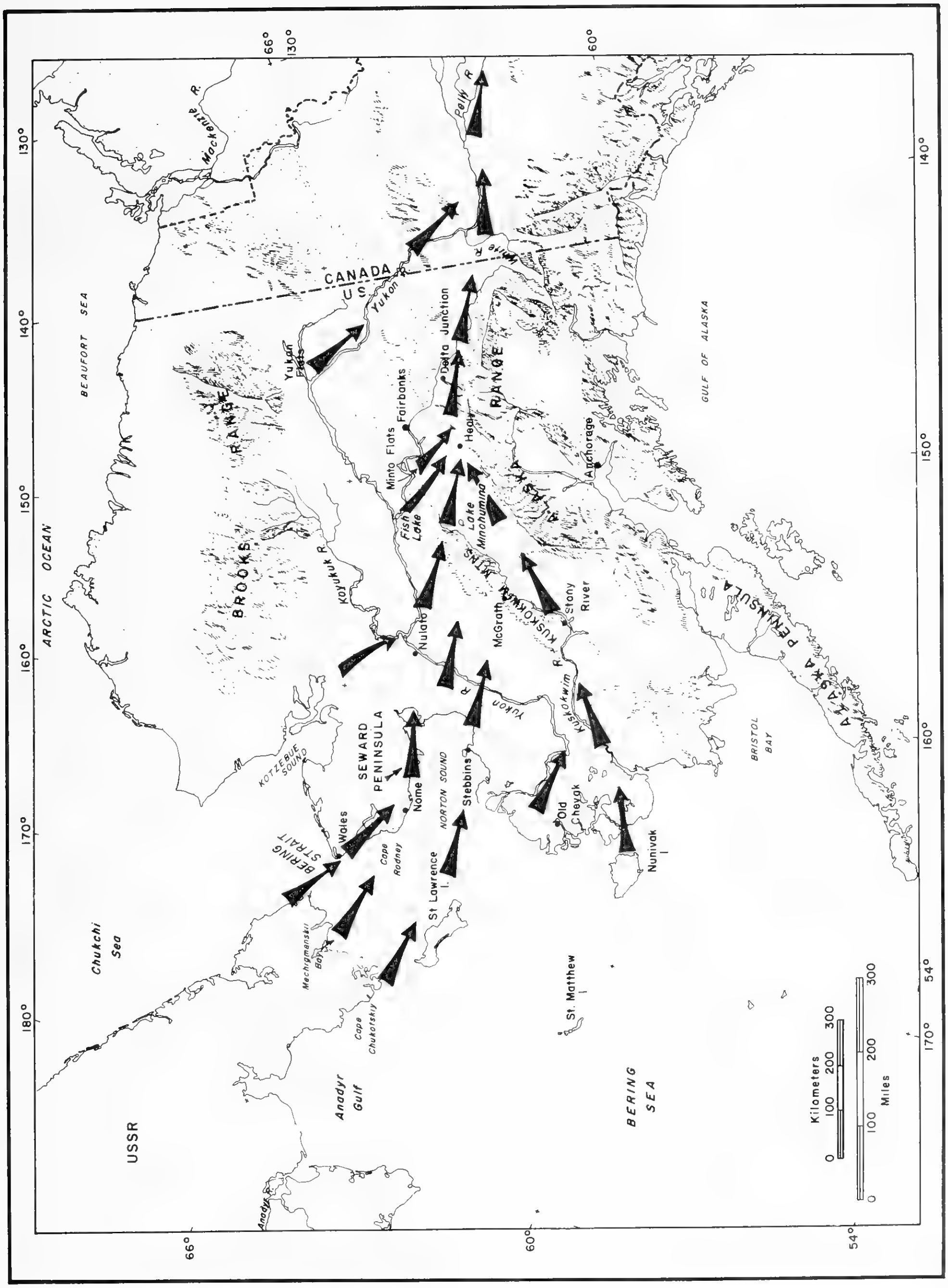

FIGURE 6. Migration pathways of Central Flyway Sandhill Cranes through Alaska.

ern Wyoming, and eastern Colorado — to their wintering grounds in southeastern New Mexico-western Texas and adjacent Mexico.

Migration Behaviour

Flight Conditions

Sandhill Cranes fly under a wide range of weather conditions, but most migration occurs on days with good visibility and high, if any, cloud ceilings (this study; Toepler and Crete 1979; Anderson et al. 1980; Melvin and Temple 1982). Sometimes, however, cranes fly during inclement weather: About 400 cranes continued flying in a heavy rainstorm along the Alaska Highway at 1400 AST on 12 September 1977. On 19 September 1977, the day of the heaviest passage that season, it had rained all night at Delta Junction and continued to rain throughout the morning, with overcast at 450 m above ground level (AGL) and scattered clouds at 150 m and lower, yet a massive movement of cranes began about 0830. Some 175 km farther east, it was foggy and snowing all day, yet 4 400 cranes crossed low (120 m AGL) over the Taylor Highway between 0915 and 1045, apparently birds that had spent the night on roosts in the valleys west of the highway; many more were heard flying above, obscured by the clouds. Weather cleared farther south over the Tanana River during the morning, and 24 000 cranes migrated along the river between 0900 and 1900, apparently including the birds that had started moving through the Delta Junction area at 0830.

On 22 September 1977, with snow falling all day and visibility less than 0.8 km, at least 2 000 cranes passed low over the Delta Junction area, and 31 cranes 50 km farther east flew in fog and snow along a valley near the Alaska Highway. On 2 May 1978 in fog and rain, a flock of 600 birds flew low over the Tanana River — following the channel of the river because of the poor visibility, instead of taking the usual shortcut across a bend and over a high ridge.

In all these situations, when cranes flew during inclement weather, barometric pressure was rising in areas toward which the cranes were flying.

Occasionally, bad weather forces flying birds to land (this study; Toepler and Crete 1979; Anderson et al. 1980; Melvin and Temple 1982). We found that poor visibility (primarily from fog and snow), heavy rains (but not medium to light rain or drizzle), and strong headwinds (40-55 km/h) were most likely to halt crane migration. On the morning of 19 September 1978, a weather front moved westward, bringing snow, rain, and fog, and caused a flock of 1 000 cranes to wheel as it came up over the Taylor Highway ridge and to settle into a valley west of the ridge. On that same day at Delta Junction, even though flying conditions appeared favorable, migrants arriving from the west began landing on the Delta River bars in mid-morning — apparently sensing the bad weather approaching from the east, even though the rain did not reach Delta Junction until noon. During an all-day snow storm the next day, four cranes landed on the Taylor Highway itself, and a flock of 20 birds landed and fed on an alpine shoulder of Mt. Fairplay. An all-day passage of over 26 000 cranes through the Delta Junction area was temporarily halted by storm clouds and heavy rains on 1 May 1978. The cranes shifted their route as the storm moved in at 1300 and the winds changed from 8-13 km/h ESE to 24-32 km/h NE; and, as the storm filled the valley, the birds dropped low and eventually landed on farm fields. Many of the grounded birds took off again on their westward migration later in the afternoon when the storm had passed.

Adverse weather along the cranes' migration routes, by periodically blocking migration, causes flocks to bunch together and is the main cause of the daily variation in numbers of cranes that pass a location. Days of big movements past Delta Junction in both spring and fall occurred after periods of few cranes (see Figures 1 and 2) and with improving weather conditions.

Flight Heights

In fall, most cranes flew between 300 and 600 m AGL, although a number of flocks flew as low as 150 m; flight heights in fall seldom exceeded 900 m. In spring, heights of 900 m were common, and few flocks flew lower than 300 m unless near roosting and feeding areas. Until 11 May in spring, flight heights of 1 200-1 800 m were recorded on some days, and on 3 days (4-6 May 1979) some flights along the Alaska Range were recorded at 2 100-2 400 m AGL.

The generally higher flights in spring than in fall and the extremely high flights on a few days in early May may be associated with unstable patterns of surface winds and updrafts caused by the sharp changes in night-day temperatures in May and by the temperature differences over snow-covered vs. snow-free surfaces. At these higher altitudes cranes could be avoiding turbulence caused by the cold, ground-level air contacting the warm, upper layers.

The mean height of flocks migrating through the upper Tanana River Valley was lower in bad than in good flying weather.

Flight Speeds

The normal flight speed of migrating cranes in the upper Tanana River Valley was about 50-55 km/h, based on timing with an automobile speedometer and on six instances of timing flocks over the 175 km between Delta Junction and the Taylor Highway area. Flocks were monitored at 90-110 km/h when flying

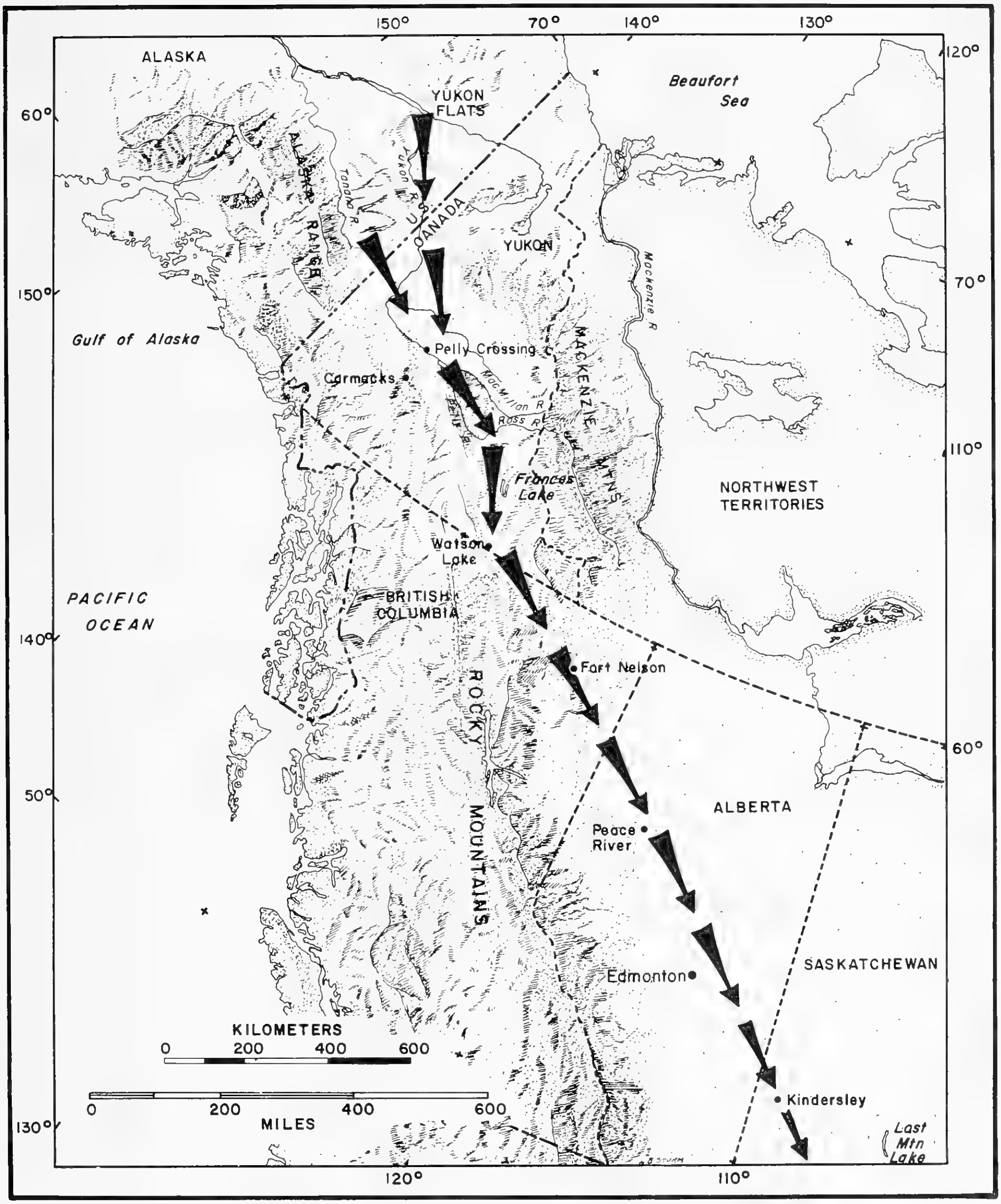

FIGURE 7. Migration pathway of Alaska Central Flyway Sandhill Cranes through northwestern North America.

with strong tail winds. Flights were correspondingly slowed by head winds, with cranes having difficulty flying against winds as strong as 30-50 km/h. These flight speeds are comparable to those previously reported (Walkinshaw 1949; Toepler and Crete 1979; Anderson et al. 1980; and Melvin and Temple 1982).

Roosts and Roosting Times

Ground use by migrating cranes in the upper Tanana River Valley is confined primarily to overnight roosting and feeding and to periods of inclement weather. The region is not a staging area in the sense of the Jasper-Pulaski area, northern Indiana, or the Platte River, Nebraska, where birds remain for a period of time to rest and replace energy reserves (Toepler and Crete 1979; Iverson 1981; Krapu 1981).

Roosting sites in the upper Tanana River Valley were characterized by openness, a situation that presumably provides a degree of protection from potential predators. Throughout North America cranes apparently prefer roosting sites that are isolated from disturbances and provide unobstructed views of surrounding areas (Lewis 1976; Krapu 1981; Lovvorn and Kirkpatrick 1981). Four basic types of overnight roosts were used in the upper Tanana River Valley: 1) alluvial islands of wide, braided, glacial riverbeds, 2) extensive wet meadows or those at pond, lake, or creek margins, 3) open, low shrub meadows or bogs, and 4) agricultural fields. Additionally, in spring, some flocks roosted on river overflow ice and on the ice of ponds and lakes.

As along the Platte River in Nebraska (Krapu 1981), alluvial islands, surrounded by river channels, seemed to be the preferred roosting habitat in eastern Alaska. This habitat was used wherever its presence coincided with appropriate roosting times. There were indications that fall migrants stopped earlier in the day near the Delta River islands roost than farther east where cranes overflew shrub bogs and wet meadows. Farm fields were the least used for roosting and were used less in fall than in spring, probably because of hunting activity. Most cranes at Delta Junction fed on the fields in the evening and morning, but roosted on river bars 10-13 km away. On 9 May 1979, however, 400 cranes spent the night in a large, newly-cleared field, roosting on exposed soil beside small snow-melt ponds between rows of piled trees.

There were several major roost areas in the region and a number of minor sites. Use of these sites varied with the size of the day's passage and with the route followed through the region. The roost used most consistently and by the largest numbers of cranes (>5 000) was the braided bed of the Delta River. The braided riverbed of the White River, Y.T., 300 km farther east, appeared to provide an equally important roosting area. Other major sites were Mosquito Flats and the Tanana River flats from south of Tetlin Junction to Northway (Figure 4). At least 15 minor roosting sites were identified along the Tanana River Valley (mostly braided riverbeds) and in the drainages of the Tanana-Yukon Highlands (mostly low shrub meadows and bogs along creeks).

During September, cranes seldom began leaving their roosts before 0500 AST — essentially at sunrise in early September but barely light enough for vision at the beginning of Civil Twilight in late September. Often, however, for no evident reason, flocks did not begin to vacate roosts until 0600-0630, or sometimes even 0700 or 0800. Weather conditions sometimes further delayed roost departures. Flocks usually remained at roosts until morning ground fog had dissipated, sometimes as late as 1000. Departure was also delayed for several hours when winds were strong. On 12 September 1978, with east winds of 30-50 km/h, cranes did not begin to leave the Delta River roost sites until 0900, and they had so much difficulty flying against the wind, especially the 65 km/h gusts, that they landed on nearby farm fields. On 18 September 1978, with 22 km/h headwinds, roosts on the Delta River did not begin to break up until 0830, and a nearby roost of 2 000 birds did not leave until 1100.

Except when weather delayed departure, cranes usually left the roost gradually. Birds sometimes remained at the roost for an hour or more after awakening — stretching, preening, "dancing," and apparently feeding. Then the exodus itself might continue for an hour, with some birds recommencing their migration and some flying to nearby river edges or farms to feed 15-75 min before continuing migration.

Aside from the daily light cycle, the time of evening roosting seemed dependent in large part upon the proximity of a favored roosting site after 1430. Birds sometimes landed to feed on farm fields at Delta Junction as early as 1430, and several times birds settled on roosts on the Delta River at 1500–1530 (once, on 25 September 1976, at 1435 in strong winds). Most often, however, they went to roost between 1600 and sunset (about 1800). In the Taylor Highway area, the birds often continued to fly 1.0 to 1.5 h later in the evening than at Delta Junction.

The difference in fall roosting times between these two areas suggested that the Delta River was a preferred roosting area. The next major "preferred" site appeared to be the braided glacial bed of the White River in Yukon Territory. Perhaps birds that passed the Delta River too early for roosting attempted to reach either the Mosquito Flats or the White River before dark, but put down on alternative roost sites if darkness overtook them. This hypothesis is supported by observations on 18 September 1977, when cranes stopped moving through Delta at 1415, but large

numbers of incoming cranes put down on the Delta River bars as late as 1830.

During spring migration, daylengths at 65° N are so long (approximately 20 h) that daylight is not the constraining influence that it is in fall; hence, times of leaving and entering roosts were more variable. In spring, cranes usually did not leave their roosts before 0530–0600. On 8 May 1978, however, 450 cranes gradually left a Delta River roost from 0400 to 0430 (Civil Twilight began at 0128), and on 11 and 12 May 1979, several small groups of cranes were heard passing overhead between 0300 and 0330–birds that apparently came off nearby river bars, since there had been no evidence of night flights farther east the previous evening. Birds from these early roost departures appeared to head for local farm fields to feed. The most frequent hour for actual migration to get underway in spring was between 0610 and 0730, either directly from roosts or after feeding in nearby fields and meadows. Occasionally, some birds would continue to arrive at feeding fields as late as 0830 and not leave on migration until after 0930, and once, on 5 May 1978, birds from a wet meadow roost did not depart until 1000.

In the evening during spring migration, some migrants dropped into the farm fields to feed as early as 1400–1500, but more frequently they did not stop until 1800–1900. Observations of actual roosting times in spring were few, but cranes were seen entering roosts between 1700 and 2115.

Occasionally a few cranes stopped during the day to feed on farm fields. On 7 May 1978, during a day-long passage of over 35 000 cranes, there was a slow turnover of cranes using a field at Delta Junction throughout the day, but there were fewer than 200 cranes on the ground at any one time.

Daily Migration Times

Sandhill Cranes are primarily daylight migrants (this study; Lewis 1976; Anderson et al. 1980; Melvin and Temple 1982), and we found almost all of their activity occurring between the beginning of Civil Twilight in the morning and the end of Civil Twilight in the evening. Occasionally, however, migratory movement continues after dark (this study; Lewis 1974; Anderson et al. 1980; Herter 1982).

We recorded night migration five times during the fall. Several flocks flew over the Taylor Highway on the clear night of 19 September 1977 at 1900 and 2000; during a snowstorm that had lasted all day on 22 September 1977, cranes were heard passing overhead as late as 2000 and 2100 (Civil Twilight began at 1848); and migration continued at least until 1920 on 16 September 1978. At Delta Junction, on 14 September 1978, cranes were heard flying at 2100 and later; and on 15 September 1978, a clear, calm, near-full moon night after a major passage, cranes were heard over Delta Junction at 2100 and over the Taylor Highway at 2115.

With the long daylight hours during spring migration, flying into the "night" hours was more frequent than in fall. On the nights of 30 April and 1, 2, and 4 May 1979, small flocks passed over the Taylor Highway until 2300; and on 6 May 1978 and 9 May 1979, cranes flew over the Delta Junction area as late as 2200 and 2145, respectively. On 5 May 1979 at 2000 and 8 May 1979 at 0330 small flocks were heard passing over the Taylor Highway.

Conclusion

This paper presents information on a number of previously unknown aspects of Sandhill Crane migration in northwestern North America, including the dates and size of movement, migration routes, and flight and roosting behaviour. About half of North America's Lesser Sandhill Cranes migrate through east-central Alaska during a 2- to 3-week period each fall and spring, with ground use limited primarily to overnight roosting. They are part of the Central Flyway population, summering throughout most of interior and western Alaska and in northeastern Siberia and wintering in eastern New Mexico–western Texas and adjacent Mexico. Except for minor differences caused by northern environmental conditions (long daylengths, ice and snow cover, taiga habitats), migration and roosting behaviours are similar to those reported for Sandhill Cranes in other regions of North America.

Acknowledgments

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An Evaluation of Spring and Autumn Trapping Seasons for Muskrats, *Ondatra zibethicus,* in Eastern Canada

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Parker, G. R., and J. W. Maxwell. 1984. An evaluation of spring and autumn trapping seasons for Muskrats, *Ondatra zibethicus,* in eastern Canada. Canadian Field-Naturalist 98(3): 293–304.

A study of spring and autumn trapping seasons for Muskrats (*Ondatra zibethicus zibethicus*) was conducted over a three-year period on the marshes of the Tintamarre National Wildlife Area in southeastern New Brunswick. A population subjected to an estimated removal rate of 60% both spring *and* autumn experienced a sharp decline in densities. Similar removal rates at other areas during spring *or* autumn did not lead to population declines. Reduced densities (increased mortality) stimulated precocial breeding by young-of-the-year and subsequent higher juvenile:adult autumn ratios. Pelts from a spring-only season were larger than those trapped in autumn but damage from fighting reduced their value to that of smaller autumn-caught Muskrats. In the first year monetary return from a spring-autumn season was 44% greater than for an autumn-only season; by the third year the return from the spring-autumn season was 6% less than that of an autumn-only season. The proportion of juveniles in the autumn harvests ranged from 84% to 96%. Adult male:female ratios for spring and autumn harvets were 0.78:1.00 and 0.82:1.00, respectively, while juvenile sex ratios were 1.29:1.00 and 1.22:1.00, respectively. The mean placental scar count for adult females which had given birth was 19.8. Embryo counts averaged 8.4/pregnant female; the average number of litters/season was 2.36. The average weight gain for juvenile males and females through the summer was 7.5 and 7.1 g/day, respectively. During the three years of study, first litters appeared from the first through the fourth week of April.

Key Words: Muskrat, *Ondatra zibethicus,* New Brunswick, trapping, economic value, growth rates, reproduction, sex and age structure.

The Muskrat (*Ondatra zibethicus zibethicus*) is the most common and widespread of the important furbearers in North America. The species has been studied extensively throughout much of its range and most studies suggest that densities of unconfined populations are controlled more by disease and weather than by trapping pressure.

Muskrats are known to disperse during spring breakup, a characteristic which leads to rapid colonization of favourable habitat. Females are prolific, and few spring breeders are required to ensure rapid population growth. This apparent resiliency of Muskrat populations has led to very liberal trapping seasons with little regard to regulating harvests relative to optimum pelt quality or value, maximizing productivity, minimizing natural mortality and other population parameters.

Muskrats are found in all four Atlantic provinces. In Newfoundland, where populations have experienced dramatic declines over the past few years (coinciding with the introduction and expansion of the Mink, *Mustela vison*), there is no public trapping season for Muskrats. In Nova Scotia and Prince Edward Island the Muskrat is an important furbearer which can only be harvested in the autumn. In New Brunswick Muskrats may be harvested in the autumn and also during a special spring season.

Substantive gains in the monetary value of raw furs within the past few years have stimulated increased trapping pressure, a phenomenon of particular concern in the Maritimes where the unrestricted sale of trapping licenses leaves the welfare of many furbearer populations susceptible to the whims of the fashion industry. The Muskrat represents approximately 10–15% of the total value of raw furs exported from Nova Scotia and New Brunswick and is ranked fourth in both provinces relative to monetary value.

From spring 1978 through autumn 1980 a controlled study on the Tintamarre National Wildlife Area in Westmorland County, New Brunswick, was designed to examine the possible changes in the abundance and reproduction of Muskrats and the quantitative market value of their skins in response to different harvest periods. The study area represented the most productive Muskrat habitat in New Brunswick. More Muskrats are harvested in Westmorland County than any other county in the province.

Methods

The Tintamarre National Wildlife Area consists of approximately 1940 ha (4800 acres) of federally (Canadian Wildlife Service) owned woods, uplands and marsh located within the Tantramar Marshes (Figure 1), and is managed in cooperation with Ducks Unlimited (Canada) for the production of waterfowl. A series of specially designed impoundments, ditches and water control structures has developed much of the area into optimum habitat for Muskrats (Whitman 1982).

The numbers and distribution of Muskrat lodges

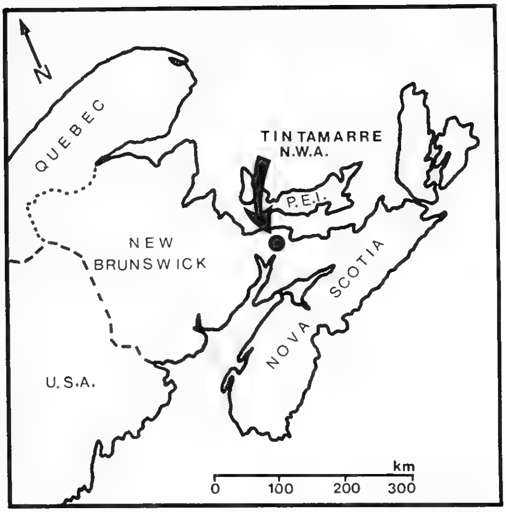

FIGURE 1. The Tintamarre National Wildlife Area is located on the Tantramar marshes in southeastern New Brunswick.

over most of the National Wildlife Area was determined by an aerial survey in autumn, 1977. Of the six impoundments available, three were selected for study, based upon similarity of size and comparable densities of lodges. Two (S and A) were adjacent and separated by an earth dike; the third was approximately 0.4 km distant. The three impoundments were closed to public trapping (adjacent areas were open), and will be referred to as Impoundments S, A and SA. Impoundment S (21.0 ha) was trapped only during the spring public trapping seasons from 1978 to 1980. Impoundment A (18.2 ha) was trapped only during the autumn seasons, and Impoundment SA (15.0 ha) was trapped during spring and autumn seasons throughout the three-year period of study. With few exceptions the authors carried out all spring and autumn trapping, participated in most of the summer live-trapping and performed all the weighing, measuring and skinning of carcasses.

Fifty traps were distributed throughout each impoundment. Traps consisted of #110 and #120 Conibear, #1 Stoploss and #1½ Victor long-spring types. Traps used depended upon the location of set. Long-spring traps were always used as drowning sets whereas stop-loss traps were used as drowning sets and where the depth of water did not justify the use of long-spring traps. Conibears were set at entrances to underwater burrows and partially submerged near lodges, feeding sites and other locations where Muskrats left and entered the water.

We attempted to simulate moderate to heavy trapping pressure. Trap sets were normally moved after several nights of inactivity. Most traps were set and checked from a canoe; others were set, mostly at entrances to underwater burrows, by walking the dikes of the impoundments. Traps were distributed throughout an impoundment the first day. Trapping continued until the daily catch declined to 0–1 Muskrats. The Muskrats caught each day were tagged and hung to dry overnight. Each Muskrat was weighed (g), measured (in mm from tip of nose to tip of tail) and sexed before skinning. Skins were dried on wire stretchers. Muskrats were aged as juveniles ($<$ 1 yr) or adults by examination of the molar fluting (Olsen 1959). Pelts were examined and scars counted. Reproductive tracts of all females were examined and the number of placental scars recorded. Pelts from each impoundment were shipped separately for sale at the Ontario Trappers Association (OTA) fur auction at North Bay, Ontario. Revenues received from the furs were distributed among those trappers who had been temporarily displaced from the study area.

During the summers of 1978, 1979, and 1980, Muskrats were live-trapped, weighed, sexed and ear-tagged in all three impoundments. Traps used were double-door Tomahawk live-traps (Tomahawk Live Trap Co., Tomahawk, Wisconsin); ear-tags were monel metal #3 (National Band and Tag Co., Newport, Kentucky). Except for very small kits, all first-captures of live-trapped Muskrats were sedated with ketamine hydrochloride (Rogar/STB, London, Ontario). Most recaptured Muskrats were handled without the use of the drug.

Results

Annual harvests

Numbers

A total of 763 Muskrats were harvested from spring 1978 through autumn 1980, 42% from Impoundment SA, 34% from Impoundment A and 24% from Impoundment S. Impoundment SA contributed 48% of the harvest in 1978 but declined to 34% by 1980 (Figure 2). The three-year decline in Impoundment A (96 vs. 79) was not significant ($\chi^2 = 3.0$; $p > 0.05$). In Impoundment S the increase in harvest between 1978 and 1979 was significant ($\chi^2 = 9.6$; $p < 0.005$) as was the decline between 1979 and 1980 ($\chi^2 = 6.1$; $p < 0.02$) but the change between 1978 and 1980 was not ($\chi^2 = 0.02$; $p > 0.05$). Impoundment SA experienced a 49% decline in the number of Muskrats trapped over the three-year period (141 vs 71; $\chi^2 = 34.7$; $p < 0.001$). The spring harvest in that impoundment declined by 64% (55 vs 20; $\chi^2 = 22.3$; $p < 0.001$) and the autumn harvest by 41% (86 vs 51; $\chi^2 = 14.2$; $p < 0.001$).

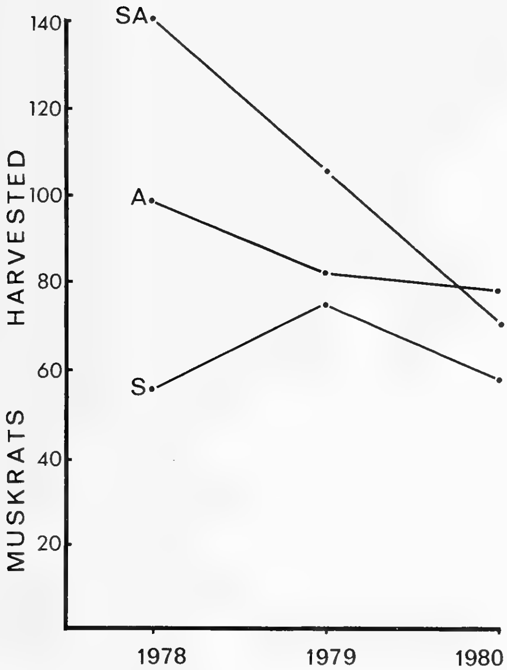

FIGURE 2. Changes in the contributions to annual harvests by the three study impoundments subjected to different seasonal trapping pressures.

Composition

The proportions of juveniles (< 1 yr) in the three-year harvest from Impoundment S and A showed no significant changes or trends, although the three-year average for Impoundment A was slightly less than for Impoundment S (85% vs 88%). Although the proportion of juveniles in the 1978 spring harvest in Impoundment SA was similar to harvests in Impoundment S, declines occurred in the springs of 1979 and 1980 (Figure 3). Although those declines appear impressive, differences are not significant (2 × 3 contingency tables; $\chi^2 = 2.58$; df = 5; $p > 0.05$), due mainly to the small samples (harvests) in spring 1979 (n = 20) and 1980 (n = 20). The autumn ratios of juveniles in Impoundment SA, although consistently greater than those in Impoundment A, were not significantly so. The lowest percentage of juveniles in the spring harvests, and highest in the autumn harvests, were from Impoundment SA.

Muskrats were more readily trapped in the autumn than in the spring (Figure 4). In autumn, 97% of the harvest was realized after eight days of trapping; in spring 88% of the final harvest had been removed in that time (2 × 2 contingency table; $\chi^2 = 25.53$; df = 3; $p < 0.005$). At all seasons approximately 20% of the harvest was taken the first night of trapping and after three nights 56% had been removed. The distribution of adult and juvenile males and females in the daily harvests of both spring and autumn suggested no obvious temporal sex or age selectivity patterns although juveniles did display a more predictable decline in numbers caught through time (Figure 5).

Males comprised a greater proportion of the juveniles than adults (Figure 6). Juvenile males were most dominant in the autumn-only season and least dominant in the spring-autumn season. The overall adult male:female ratios for spring and autumn harvests were 0.79:1.00 and 0.83:1.00 ($p > 0.05$), respectively. The juvenile male:female ratios for spring and autumn harvests were 1.29:1.00 and 1.22:1.00 ($p > 0.05$), respectively. The proportion of males in the adult samples was significantly less than in the juvenile samples for spring ($\chi^2 = 4.98$; df = 1; $p < 0.05$) and autumn ($\chi^2 = 9.88$; df = 1; $p < 0.005$) harvests.

Productivity

The count of placental scars in female Muskrats is a reliable method of determining the number of embryos per breeding female (Gashwiler 1950; Schacher and Pelton 1976).

Of 763 Muskrats harvested over the three-year study period, only 36 were adult females (> 1 yr) which had previously given birth. The mean counts of placental scars, by impoundment, are shown in Table 1. Differences in placental scar counts for the

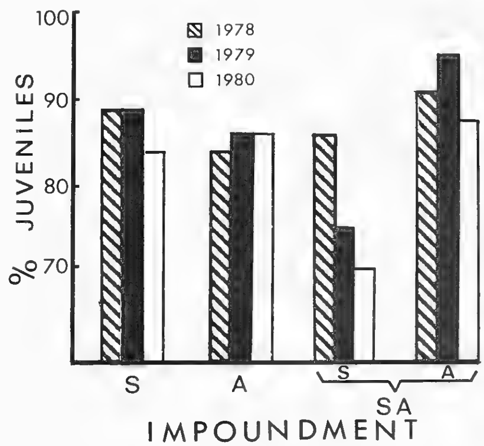

FIGURE 3. Changes in the proportion of juvenile Muskrats in the seasonal harvests from the three study areas subjected to differential trapping pressure.

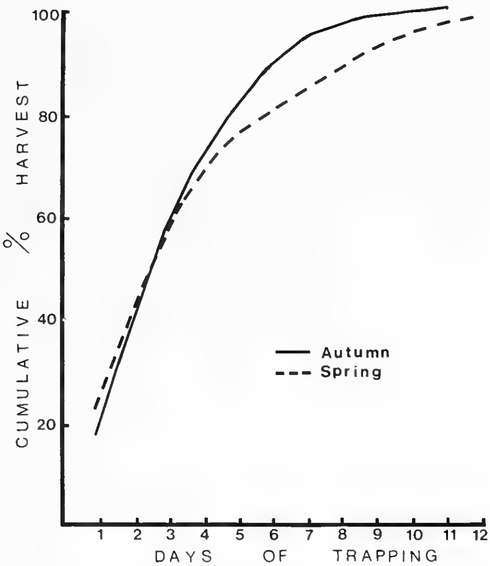

FIGURE 4. Allocation of spring and autumn harvests to day of trapping; Muskrats were more readily trapped in autumn than in spring.

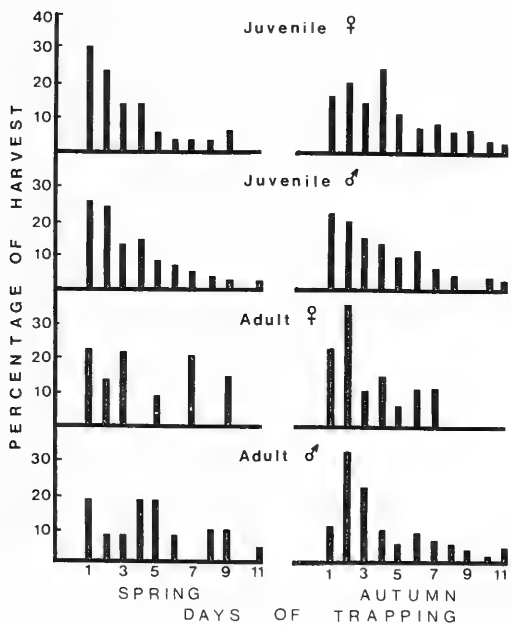

FIGURE 5. The temporal distribution of adult and juvenile males and females during spring and autumn harvests (1978–1980).

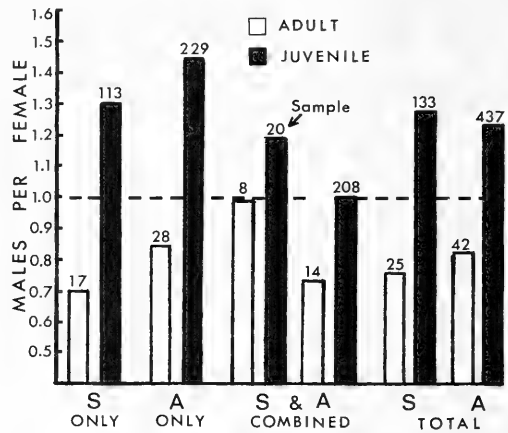

FIGURE 6. The disproportionate sex ratio of harvested adult and juvenile Muskrats; the representation of females was greatest in the population subjected to the highest mortality.

three impoundments were not significant ($p > 0.05$). The mean placental scar count for all impoundments was 19.8.

In spring 1979, breeding was early, and nine adult females trapped during the public trapping season were pregnant with visible embryos. Eight of the pregnant females were from Impoundment S. The mean number of embryos/pregnant female was 8.3 ($s = 1.3$). The one pregnant female from Impoundment SA carried nine embryos. The overall average was 8.4 embryos/pregnant female ($s = 1.2$). Assuming the 8.4 embryos was representative of all impoundments over the three-year period, the average number of litters/season was 2.36.

Eight females (5 — autumn; 3 — spring) had given birth to (or were carrying) one litter, and all eight were aged by molar fluting as being < 1 year old. All eight precocial females were caught in Impoundment SA. The mean litter size of those early breeders was 7.5, slightly less than the 8.4 mean litter size for females > 1 year old.

Eight of the 19 females (42%) from Impoundment SA bearing scars were < 1 year old. Five percent of females < 1 year old and removed from Impoundment SA were pregnant or had given birth to one litter. As many of those juvenile muskrats examined were autumn-caught and from second or third litters, the actual percentage of juveniles which had bred their first summer would have been considerably higher. No muskrats < 1 year old from Impoundments S or A were pregnant or had given birth.

One female, ear-tagged as a 825 g juvenile on 29 August 1980, was pregnant when caught later during

TABLE 1. Placental scar counts for females (> 1 yr) harvested spring and autumn, 1978–1980. Sample size in parenthesis.

Year/Season	$\bar{x}$ placental scars/impoundment			Total
	S	A	SA	
1978: Spring	23.3(3)		20.5(2)	22.2(5)
Autumn		15.5(7)	23.0(2)	17.2(9)
Subtotal	23.3(3)	15.5(7)	21.7(4)	19.0(14)
1979: Spring	embryos		embryos	
Autumn		17.2(5)	28.0(1)	19.0(6)
Subtotal		17.2(5)	28.0(1)	19.0(6)
1980: Spring	20.8(5)		21.0(1)	20.8(6)
Autumn		22.8(6)	18.5(4)	21.1(10)
Subtotal	20.8(5)	22.8(6)	19.0(5)	21.0(16)
Totals	21.7(8)	18.4(18)	21.0(10)	19.8(36)

the autumn trapping season. That Muskrat would have been from an early spring litter. It is interesting to note that the latest recorded pregnancy of a muskrat in eastern Canada (Parker 1979) was also trapped from Impoundment SA, 6 November 1978.

An indication of relative productivity can also be obtained from the proportion of juveniles in the harvests. Impoundment SA produced the greatest proportion of juveniles in the autumn harvests ($\bar{x}$ = 92%). The proportion of juveniles in the spring harvest was low (81%) but that may have resulted from selective autumn trapping pressure and/or selective overwinter mortality.

Population trends

The capture and ear-tagging of Muskrats in the summer provided a means of monitoring population trends in the three impoundments over the three-year study period. The capture locations of tagged Muskrats also provided information on dispersal and discreteness of study populations. Application of the Lincoln Index to the tagging and harvest data gave projected estimates of pre-trapping seasonal densities. Knowing the number of Muskrats removed each season, population estimates from mark-recapture data were used to estimate rates of removal. Rates of removal in spring varied from 11–41% ($\bar{x}$ = 32.5%; s = 14.3%) and in autumn from 56–62% ($\bar{x}$ = 58.8%; s = 2.3%). Estimated rates of removal in autumn were consistently higher and showed less variability than those for the spring. Estimates of densities and rates of removal from mark-recapture data during the spring harvest were probably low due to overwinter tag loss and spring dispersion of tagged animals.

Tagging showed that the study areas did not represent closed populations. In summer, 1978, 225 Muskrats were ear-tagged in the three impoundments. Persons trapping adjacent wetlands were made aware of the program and of our interest in being notified of recovered tags. In autumn, 1978 all tagged Muskrats recovered during the public trapping season were within the impoundments of original capture. Of the 161 tags applied in the two impoundments trapped in autumn, 100 (62%) were recovered. Of the 61 tagged Muskrats which may have survived overwinter and been available for capture in spring, 1979, 7 (11%) were returned from adjacent wetlands. In that impoundment not trapped in autumn, 64 Muskrats had been tagged during summer, 1978. None were recovered during the public trapping of adjacent wetlands in autumn, 1978. In spring, 1979, 7 (11%) were trapped outside the impoundment of original capture.

Based upon these reports, approximately 11% of Muskrats participate in spring dispersal. That rate of dispersal is conservative as it does not take into consideration the natural loss of tagged Muskrats overwinter and the fact that not all dispersed Muskrats are trapped. The rate of spring dispersal probably approaches 20% of the spring population. Of the 14 Muskrats trapped outside the impoundment of tagging, 7 were juvenile females, 6 were juvenile males and 1 was an adult male.

Due to dispersion and overwinter tag loss, rates of harvest of spring populations based upon Lincoln Index calculations are probably low. In this study, where trapping methodology and intensity were controlled, seasonal densities are best calculated by assuming that the level of harvest represents a constant rate of removal, i.e. 60%. Seasonal population estimates for the 3 impoundments are shown in Table 2. Population estimates for autumn- and spring-autumn harvested impoundments declined over the three-year study period; densities in the spring-harvested impoundment remained relatively constant.

Economic return

The 763 muskrats removed from the three impoundments realized a net return from the OTA fur

TABLE 2. Population estimates for the three study impoundments, assuming seasonal harvests represented 60% of the actual population [harvest estimates for autumn populations, based upon mark-recapture data (Lincoln Index) range from 56–62% ($\bar{x}$ = 58.8; s = 2.3; n = 6)].

		Year and season					
		1978		1979		1980	
Impoundment	Harvest	S	A	S	A	S	A
S	Spring*	90		130		93	118
A	Autumn		160		136		131
SA	Spring-Autumn	90	143	33	141	33	90

*Impoundment S also harvested during last trapping season in autumn 1980.

auction at North Bay of $5817.87 (Table 3). Similar to the trend in the numbers of muskrats harvested over the study period, Impoundment SA contributed 50% of the total revenue received in 1978 but only 35% in 1980. Over the three-year period Impoundment S, A and SA contributed 24%, 36% and 40%, respectively, of the total economic return. The autumn harvests contributed 67% of the return over the three-year period.

Total revenue from Impoundment SA declined 26% from 1978 to 1980, although the average price/pelt from that impoundment increased from $5.43 in the spring of 1978 to $9.25 by the autumn of 1980 (Table 4).

The increase in the value of pelts during the three-year period was much greater for Muskrats caught in the spring than for Muskrats caught in the autumn. The average value of Muskrats trapped in the spring increased by 73% in Impoundment S and by 90% in Impoundment SA. The value of Muskrats caught in the autumn increased by 38% in Impoundment A and 37% in Impoundment SA.

Physical characteristics

Muskrats harvested in the spring were heavier than those in the autumn harvest; seasonal differences were greatest for Impoundment SA (Figure 7). The mean weights for male and female Muskrats in the spring were 1365 g and 1275 g, respectively; autumn weights averaged 1133 g and 1130 g, respectively.

The mean lengths of male and female Muskrats in the spring were 597 mm and 595 mm, respectively; autumn lengths averaged 575 mm and 568 mm, respectively. Body lengths also experienced seasonal differences, and, as with body weight, those differences were most pronounced in Impoundment SA.

There were no significant differences ($p > 0.05$) in mean body lengths or weights between impoundments. There were no significant changes, or apparent trends, in weight or length of Muskrats from Impoundment S and A over the three-year period. Males from Impoundment SA also showed no apparent trend in weight or length. In spring 1980, females were heavier ($p > 0.05$) than those harvested in spring 1978. In autumn 1980, females were shorter ($p < 0.01$)

TABLE 3. Revenues ($$) received from sale of muskrat pelts, by impoundment and season, 1978–1980.

	Impoundment			
Year/Season	S	A	SA	Totals
1978: Spring	308.70		292.44	601.14
Autumn		628.61	613.25	1241.86
Subtotal	308.70	628.61	905.69	1843.00
1979: Spring	561.69		67.17	628.86
Autumn		765.28	681.83	1447.11
Subtotal	561.69	765.28	749.00	2075.97
1980: Spring	511.57		202.46	714.03
Autumn		713.37	471.50	1184.87
Subtotal	511.57	713.37	673.96	1898.90
1978–80: Spring	1381.96		562.07	1944.03
Autumn		2107.26	1766.58	3873.84
	1381.96	2107.26	2328.65	5817.87

TABLE 4. Price range ($$) and mean value of pelts for muskrats harvested from Impoundments S (spring only), A (autumn only) and SA (spring and autumn) from 1978 to 1980.

	Impoundment								
	S			A			SA		
Year/season	n	range	$\bar{x}$	n	range	$\bar{x}$	n	range	$\bar{x}$
1978									
Spring	55	0.80– 8.25	5.61				55	2.75– 6.70	5.32
Autumn				96	1.90– 7.70	6.55	86	1.60– 7.70	6.77
1979									
Spring	78	1.90– 9.45	7.20				8	8.20–14.00	8.40
Autumn				82	5.90–12.35	9.33	85	0.75–12.35	8.02
1980									
Spring	56	1.00–13.65	9.14				20	5.85–14.00	10.12
Autumn				79	1.15–11.40	9.03	51	4.90–13.35	9.25

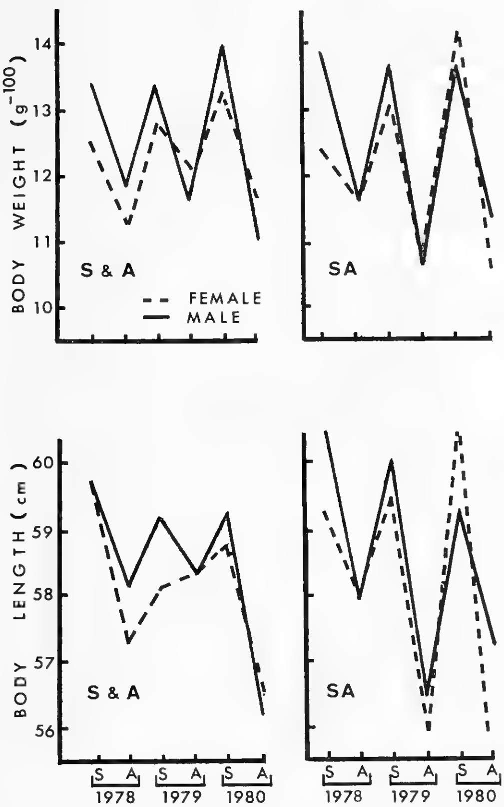

FIGURE 7. Yearly and seasonal differences in the lengths and weights of Muskrats harvested by impoundment from 1978 through 1980.

than those harvested in autumn 1978. These differences did not result from changes in physical characteristics of adults ($p < 0.01$) but rather from changes in the representation of juveniles in the seasonal harvests.

Reproduction and growth

Ninety-two juvenile Muskrats (54♂♂; 38♀♀) were weighed two or more times during the summer live-trapping programs. Only consecutive weights ≥ 8 days apart were considered. The average weight gain for juvenile males and females were 7.5 and 7.1 g/day, respectively ($p > 0.05$). No Muskrats weighed less than 200 g at first capture. Juveniles normally reach that weight before they first leave the lodge at 30 days of age and are first prone to capture (Dorney and Rusch 1953; Errington 1963; Parker and Maxwell 1980).

Annual birth dates of juveniles were calculated by back dating from first capture weights (Figure 8). We assumed average weight gains of 7.5 g/day and 7.1 g/day for male and female juveniles, respectively, and departure from the lodge at 30 days of age at 200 g.

In 1979 first litters were born in early April, in 1980 the third week, and in 1978 the fourth week. Delayed breeding in the spring resulted in an increase in litters born in late July and August. In 1978, when breeding was delayed, litter production increased rapidly through late May and then declined through early July. In 1979, when breeding was early, the frequency of litters was more widely distributed with no sharp increases or declines although a peak in litters did occur in mid-May. In 1980, when first breeding occurred between comparative dates for the previous two years, litter production appeared to be distributed about three apparent peaks, i.e. early May, mid to late May and mid-June.

Muskrats have a gestation period of approximately 30 days (Errington 1963); dates for first breeding in 1978, 1979 and 1980 were the fourth, first and third

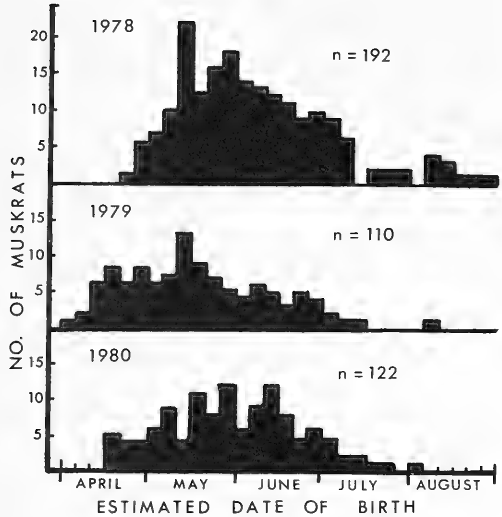

FIGURE 8. Distribution of birth dates for juveniles live-trapped and weighed during the summers of 1978 through 1980 (calculated daily weight gains were used to estimate date of birth).

weeks of March, respectively. Our data suggests that the later the spring the more concentrated the breeding.

Pelt quality

This analysis was meant to measure whether increased trapping pressure (Impoundment SA) and subsequent lower densities produced decreased pelt damage (scars/pelt) and increased pelt value. Thus, only Muskrats trapped from Impoundments S and SA were used in the comparative analysis.

Damage (scars)

In spring, many pelts of adults were damaged from fighting during the spring breeding season which contributed to reduced pelt value. Pelts from autumn-trapped muskrats were seldom damaged by scars. We found no difference in the damage to pelts between sexes. In spring, 1978, 110 pelts were examined for scar damage by sex. In that sample 85% of the males and 71% of the females showed some damage (2 x 2 contingency table; $X^2 = 3.40$; df = 3; $p > 0.05$).

We assume that the frequency and intensity of fighting in the spring is directly related to the densities of local populations. It is also reasonable to assume that the number of scars per pelt can be used as a comparative measure of the intensity of conflict and therefore a measure of population densities.

The counts of scars on spring pelts show a progressive decline for both impoundments over the three-year period (Figure 9). The proportion of pelts with no scars from Impoundment S increased from 25% to 26% to 44% (2 x 3 contingency table; $X^2 = 6.22$; df = 5; $p > 0.05$); for Impoundment SA those percentages were 15%, 40% and 65% ($X^2 = 17.37$; $p < 0.005$). Corresponding percentages for pelts with three or more scars declined from 45%, 42% to 17% for Impoundment S and 28%, 18% to 10% for Impoundment SA (no X^2 test due to low sample size). Pelts from Impoundment SA were consistently less damaged than those from Impoundment S and the proportion of pelts with no scars increased more rapidly in the former.

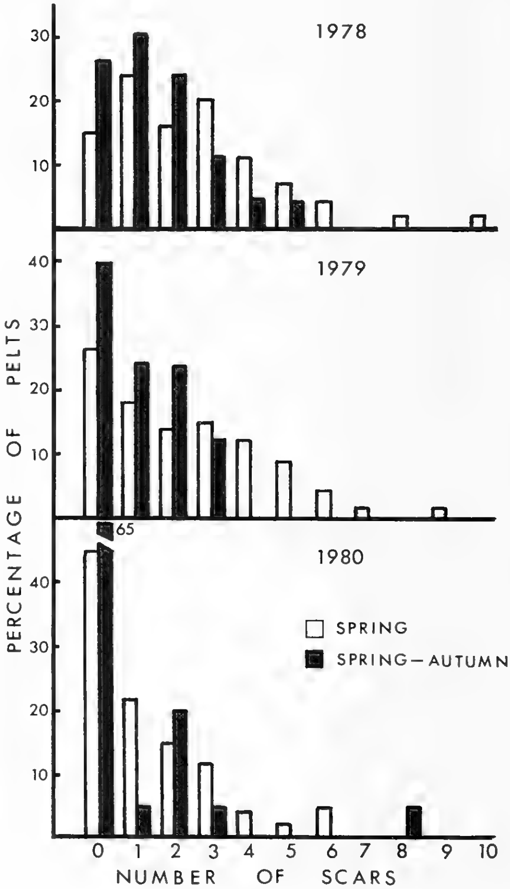

FIGURE 9. The number of scars per pelt for Muskrats harvested from Impoundments S and SA from 1978 through 1980.

Value (monetary return)

As the price paid for muskrat pelts at the North Bay fur auction increased over the three-year period, a direct monetary comparison was not practical. Instead, we divided the seasonal price range received for pelts into 10 equal classes and then calculated the proportion of pelts which fell within each. The frequency assignment of pelts into value classes did show that the overall value increased annually and the increase was more noticeable in Impoundment SA than in Impoundment S (Figure 10). The proportion of pelts in the top two value classes increased in both impoundments over the three-year study. However, whereas that increase was marginal for Impoundment S (22% vs 28%) it was substantial for Impoundment SA (0% vs 40%). The change in pelt value follows the trend in changes to pelt damage measurements.

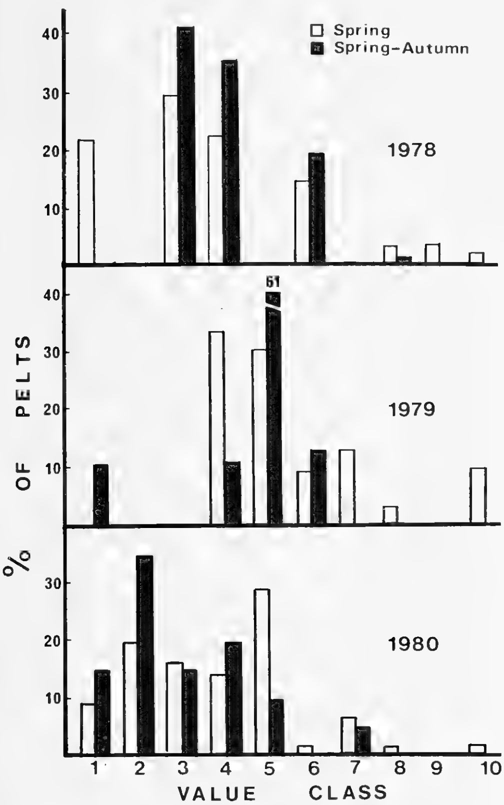

FIGURE 10. The distribution of pelts relative to value (Ontario Trappers Association Fur Auction) for Impoundment S and SA for spring harvests from 1978 through 1980. (Value class = price range for both impoundments divided into 10 equal classes i.e. class 1 = % of pelts that fell within the top 10% of price range; numerals in order of receeding value.)

Discussion

Measurements of muskrat reproductive potential in this study are high ($\bar{x}$ young per breeding female in the autumn = 19.8; $\bar{x}$ embryos in spring-caught females = 8.4); comparable litter size values from other studies in the Maritimes are 6.8 (Parker and Maxwell 1980) and 5.8 (Dilworth 1966) from southern New Brunswick and 6.7 for Prince Edward Island (Dibblee 1971). In Belgium Moens (1978) recorded an average of 7.0 scars per litter. Litter sizes show great variation in North American literature, from 4.0 in Alabama (Beshears and Haugen 1953) to 7.1 in Maine (Gashwiler 1950).

The estimated number of litters per season of 2.36 compares well with mean litter sizes for most areas of northeastern North America but is below the estimated 3.0 for muskrats in an estuarine marsh in Connecticut (Smith and Jordan 1976) and the 7–8 litters per season in Louisiana (O'Neil 1949 *cited by* Errington 1963). Our data support the hypothesis of Gashwiler (1950) that the number of litters per season decreases with latitude while the average litter sizes increase. In this way the species maintains high rates of productivity throughout its range.

Muskrats of northeastern North America are relatively uniform in size and body weight. In this study the weights of adult males and females in November were 1511 g and 1523 g, respectively. Comparative spring weights were 1483, and 1433 g, respectively. An overwinter loss of weight by adult Muskrats was also reported in Connecticut by Smith and Jordan (1976) and is attributed to declines in body fat deposits.

In autumn, immature weights varied from less than 500 g to 1400 g. The mean autumn weights for juvenile males and females were 1092 g and 1073 g, respectively. Adult weights are considerably greater than weights for muskrats in Iowa (Errington 1963) and Tennessee (Schacher and Pelton 1976), less than those for Connecticut (Smith and Jordan 1976) and slightly greater than autumn weights reported for muskrats from other areas of New Brunswick (Parker and Maxwell 1980). Juvenile weights in autumn are less than those for Connecticut, but, as with adults, the Quinnipiac Estuary near New Haven supported muskrats of unusually large body size and weight.

The productivity of the Tintamarre population varied by season and impoundment. Productivity, measured as the ratio of juveniles to adult females in the autumn and spring harvests, varied from 7.7:1.0 to 20.4:1.0. Both extremes were associated with Impoundment SA harvested both spring and autumn.

Similar to other studies, sex ratios favoured males

in juveniles and females in adults. Males comprised 44% of the adult sample, identical to that reported from northern Saskatchewan (Phillips 1979) but slightly less than in Iowa (46.3% — Errington 1963) and Wisconsin (49% — Beer and Truax 1950). In this study juvenile sex ratios favoured males, the 56% males was similar to juvenile sex ratios from other areas of eastern North America. There was general agreement between the proportion of juveniles in the autumn harvests and the mean number of placental scars from adult females. Based upon mean placental scar counts and the juvenile:adult female ratios in the autumn harvests, rates of mortality from birth to autumn varied from 29% to 50% and averaged 35% (calculations exclude the nil mortality rate for Impoundment SA in 1979 due to sample size of only one reproductive tract). Survival from birth to autumn was high (~ 65%) when compared to other populations (55% — Saskatchewan, Phillips 1979; 48% — Alberta, Stewart and Bider 1974). Errington (1963) considered 50% a good rate of survival for juveniles in most populations.

First breeding by Muskrats in the Tintamarre area varies with the year and appears dependent upon snow depths and the arrival of warm weather during late February and early March. In 1979, first-breeding began in early March. In that year snow depths were light and temperatures mild during the first week of March (Figure 11). In 1978 breeding did not begin until late March. In that year snow depths were heavy through February and well into March and temperatures remained cool throughout the month. We suggest that moderate snow cover and temperatures during February and March of 1980 influenced first breeding to begin during the third week of March.

The number of Muskrats harvested from population SA declined by approximately 60% over the three-year period, population A declined by 18% and population S remained relatively stable. Contribution to the total annual harvests by SA over the three years declined from 58% to 40% to 34%. As trapping methods and intensities remained standard, we must assume that changes in harvest levels reflect corresponding changes in densities. A spring-only season

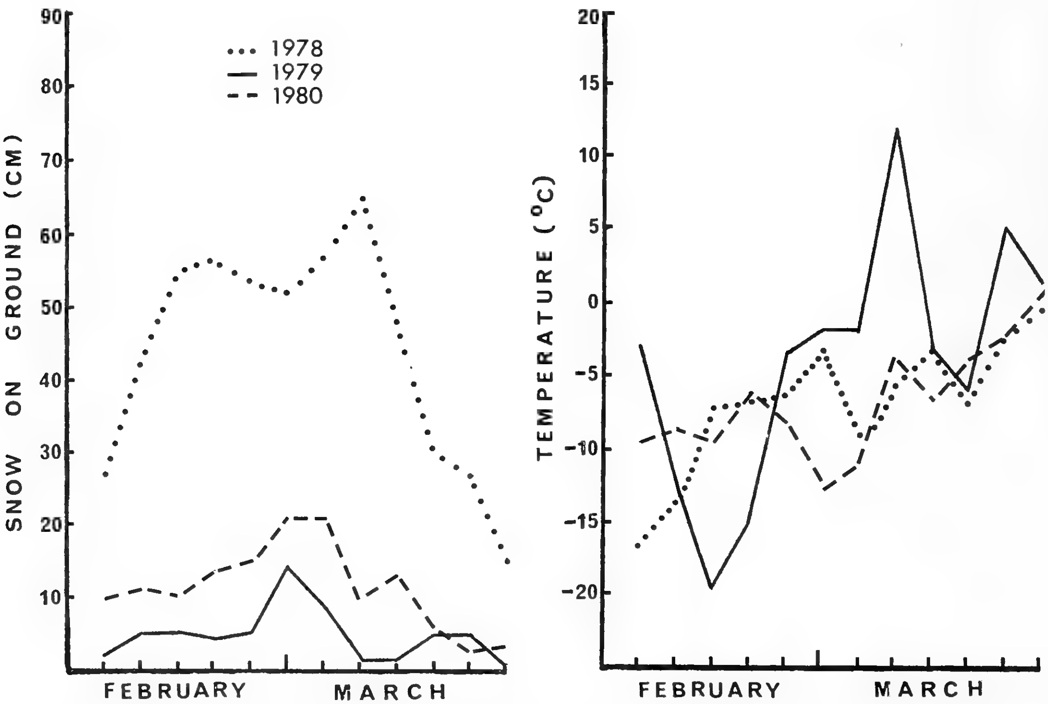

FIGURE 11. Snow depths (5 day means) and daily temperatures (5 day means) at Moncton Airport (40 km from study area) for February and March from 1978 through 1980.

had little impact upon population change. We believe that the initial decline in the autumn-only harvest resulted from low harvest levels prior to the study, i.e. an initial surplus was quickly removed followed by population stability. We suggest that the apparent numerical decline in population SA was real and resulted from sustained overharvest.

We estimated a constant seasonal removal rate of 60% of the initial populations, a rate which should not create declines in annual levels, especially in populations with proven high levels of productivity (Smith and Jordan 1976). However, the additional 60% loss of the spring population following an autumn harvest in addition to expected overwinter losses does appear to surpass the limits of removal which allow sustained yield. Although densities declined with overharvest, our data suggest that the reproductive potential and productivity increased concurrent with increased mortality. Although our data do not show that population SA produced more young per female (placental scars) the proportions of juveniles in the autumn harvests were greater than for the other two populations. Conversely, the proportions of juveniles in the spring harvests were lower than the other two populations, especially following the initial year of trapping.

In contrast to juvenile male:female ratios of 72:50 and 65:50 in harvests from populations A and S respectively, the comparative ratio in harvests from population SA was 50:50. Not only was the representation of juvenile females greater in population SA, but also the only incidences of precocial breeding occurred in that population. Forty-two percent of females from SA bearing placental scars were juveniles; 5% of all juvenile females harvested from SA were pregnant or had given birth. Thus, increased productivity (% juveniles in the harvest) was a function of precocial breeding by juveniles rather than increased young per adult female.

It is reasonable to relate precocial breeding with increased rates of juvenile body growth and development, both being a function of greater food availability and less intraspecific stress due to reduced densities. A measure of both factors is the rate of weight gain by juveniles and adults through summer and autumn. As the rate of daily weight gain (g/d) is also a function of individual body weight (small juveniles usually gain weight faster than large juveniles), weight gains were calculated for juveniles of various weight classes at initial capture. Precocial breeding within population SA should coincide with rates of body weight gain greater than for Muskrats in population A. This was found to be so (Figure 12) although large intraclass variations in measurements precluded statistically significant interclass differences. However, the weight gain for all juveniles from SA was significantly greater than for juveniles from population A

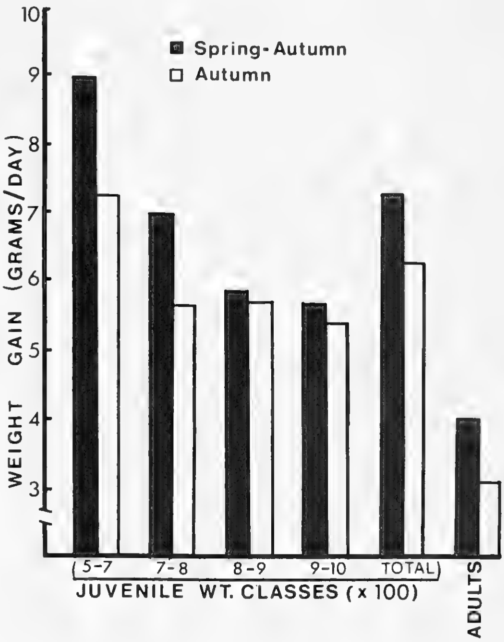

FIGURE 12. Mean weight gain (grams/day) for Muskrats live-captured in summer and harvested in autumn for Impoundments A and SA from 1978 through 1980.

($p < 0.01$). SA adults also gained weight more rapidly than those from population A, although the difference was not significant. It would be expected that weight gain differences between populations would increase through the three-year study period. No clear annual trend was apparent probably due to sample size and the aforementioned large variations in measurements.

It has been shown that increased trapping pressure, especially when applied spring and autumn, can reduce Muskrat populations. Concurrent with increased rates of mortality and reduced population levels, productivity is increased by greater representation of females in the juvenile cohort supplemented by precocial breeding. In areas where trapping pressure is uniform and sustained and immigration limited, increased productivity is not sufficient to prevent population declines. Population densities can be suppressed below optimum levels within specific habitats. Spring and autumn seasons alone did not produce population declines.

Muskrats harvested in the spring were larger than those caught in the autumn. The benefit of larger size was offset by increased pelt damage from fighting during the breeding season. The average value per pelt

for Muskrats from Impoundment A was actually greater than that for Muskrats from Impoundment S two of three years. Reduced densities in Impoundment SA, however, resulted in less pelt damage and spring prices remained much higher than for Impoundment S. Over the three-year period revenues from A were 52% greater than S, although the three-year harvest from A was greater by only 36%. A spring season is not justified by economic return.

Our data show that Muskrats are more readily harvested in the autumn. Because an early freeze can cause havoc with the autumn season, earlier trapping (mid-October) might be necessary to offset that problem. Another negative aspect of spring trapping is the mortality of substantial numbers of non-target species. In northern latitudes the severity of the problem depends upon the arrival of mild weather and the influx of migratory birds (Parker 1983).

It makes biological sense to harvest a species at the time of year when population levels are greatest. A spring season loses the opportunity of harvesting that segment of a Muskrat population lost through overwinter mortality and removes only those Muskrats which have survived the rigors of winter and therefore represent the prime breeding stock. Although the manager should consider both the trapper and the resource when formulating management programs, the welfare of the resource must receive priority. We suggest that in eastern Canada Muskrats should be harvested during an autumn-only season and the season should begin in mid-October.

Acknowledgments

We express our gratitude to the trappers on the Tintamarre National Wildlife Area who cooperated fully and helped ensure the success of the study. We thank Dale Morton and Ron Hounsell (Canadian Wildlife Service, Atlantic Region) for their assistance during several of the trapping seasons.

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Croissance, reproduction et régime alimentaire de la morue, *Gadus morhua*, vivant dans le fjord du Saguenay, au Québec

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De janvier 1975 à février 1977, 1222 morues (*Gadus morhua*) ont été capturées dans le fjord du Saguenay à l'aide de filets maillants. Il n'y avait pas de différence significative dans la croissance en longueur et en poids chez les deux sexes et ils atteignaient le même âge. Au cours de la saison hivernale, ces poissons régressaient de novembre à mars de 25 mm en moyenne; ce phénomène semble relié à une activité cyclique similaire à celle des poissons d'eau douce. La condition relative, le rapport gonosomatique et hépatosomatique de ces poissons étaient relativement constants au cours de l'année. La maturité sexuelle avait lieu à quatre ans et la période de fraye s'étendait de novembre à la fin de mars. Le nombre d'oeufs moyen par femelle était de 975 006; il augmente avec la taille et le poids des poissons et le diamètre moyen des oeufs après fixation dans le formol était de 0,72 mm. Le régime alimentaire de la morue se composait principalement de crustacés et de poissons. Il y avait aussi du cannibalisme. Enfin, ces poissons étaient impropres à la consommation humaine à cause d'un niveau trop élevé (2,20 ppm) de mercure dans les muscles.

Mots clés: croissance, reproduction, régime alimentaire, morue, *Gadus morhua*, fjord du Saguenay, Québec

For two years (from January 1975 to February 1977) 1222 cod (*Gadus morhua*) were caught in the Saguenay fjord with gill nets. Regular observation shows that there are no significant differences between sexes in their growth, length, weight and longevity. These fish decrease in length by an average of 25 mm during the winter months, November to March. This phenomenon is similar to the cyclic activity of the freshwater fish. Their relative condition, maturity, and hepatic index were relatively constant during the year. Sexual maturity was reached at four years and the spawning period was from November to the end of March. The number of eggs per female averaged 975 006. The egg number was proportional to the size and weight of the fish and the average egg diameter, after fixing in formalin, was 0.72 mm. The diet consisted mainly of crustaceans and fish, with some cannibalism. These fish were not suitable for human consumption due to the high mercury content (2.20 ppm) of their flesh.

Key Words: growth, reproduction, feeding habits, cod, *Gadus morhua*, fjord du Saguenay, Quebec.

Nous nous sommes intéressé à la biologie de la morue, *Gadus morhua*, à cause des caractéristiques hydrographiques très spéciales du fjord du Saguenay. Le fjord du Saguenay a cette particularité que ses eaux sont stratifiées en deux étages distincts séparés par une thermohalocline. La couche superficielle, qui constitue les eaux de surface, est douce ou saumâtre, mince et relativement chaude. En-dessous, on a des eaux arctiques très froides et salées qui vont jusqu'aux plus grandes profondeurs (Drainville 1968). En outre, la présence d'un seuil à l'embouchure du St-Laurent empêche le libre échange de l'eau salée avec celle du fleuve, et par conséquent, à notre avis confinait cette population de poissons au fjord du Saguenay depuis la dernière glaciation.

A cela s'ajoute le fait que la présence de ce poisson a été signalé pour la première fois dans le Saguenay au début des années soixante (Drainville 1968). Des pêcheurs en capturaient commercialement depuis 1970 et la population locale en consommait de plus en plus ignorant que cette rivière était parmi les plus polluée de toutes les rivières canadiennes (Loring 1975). Il nous a donc paru important de faire une étude de ce poisson qualitativement et quantitativement et d'en approfondir sa biologie: croissance, reproduction et régime alimentaire.

Description et faune du Saguenay

Le Saguenay, émissaire du lac St-Jean, coule sur les cent derniers kilomètres de son cours, dans un fjord atteignant 276 mètres (Figure 1). L'embouchure de cette vallée glaciaire se termine par un seuil laissant passer une couche d'eau d'environ 25 mètres d'épaisseur. La caractéristique océanographique principale du fjord est la présence d'une thermohalocline de grande intensité déterminant une stratification des eaux en deux étages: 1) la nappe superficielle (0–20 m environ) a, en surface durant l'été des températures de 16–18°C et des salinités aussi faibles que 5 ‰. Cette couche est limitée à sa base par la thermohalocline où la température descend rapidement à environ 1°C et où la salinité monte brusquement à 26 ‰ environ; 2) la nappe profonde (de 20 m environ jusqu'au fond) est plutôt isotherme avec des oscillations de température

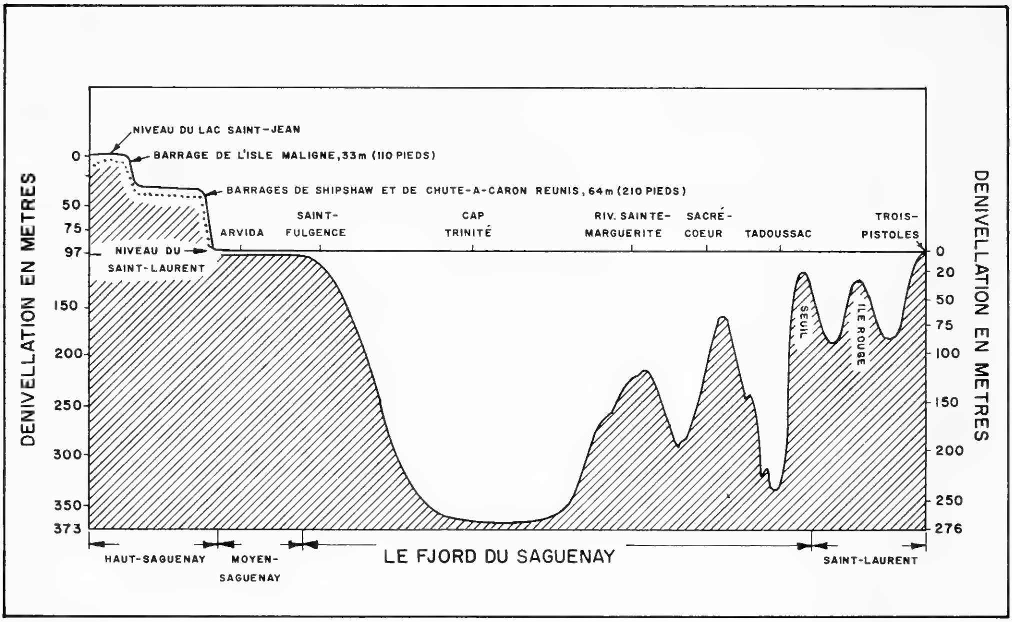

FIGURE 1. Profil en long montrant les fortes dénivellations dans le Haut-Saguenay et les grandes profondeurs du fjord comparées à celles de l'estuaire du St-Laurent pour la même latitude (Drainville 1968).

entre 0,4 et 1,7°C et possède un gradient de salinité bien régulier allant de 26 ‰ à 20–25 m, à 31 ‰ aux grandes profondeurs. Les données d'oxygène dissous indiquent une bonne aération dans les grands fonds; les valeurs sont environ 5 ppm (Drainville 1968). En hiver (surface et en profondeur) la salinité est très près de celle qu'on a en été. A l'endroit des échantillons pour le mois de janvier à avril, nous avons obtenu en surface 2,21 ‰, à 12 mètres, 19,50 ‰ et à 40 mètres 22,3 ‰. Il se peut que ces valeurs soient influencées par la marée ou encore par un débit accru d'eau douce venant du lac St-Jean. Ce dernier est utilisé comme réservoir hydroélectrique et on abaisse le niveau de l'eau de janvier à avril d'environ 3 à 5 mètres. Enfin, les sédiments sont contaminés par le mercure (Loring 1975).

La faune ichtyologique se compose de 55 espèces réparties en 21 familles. Il y a des espèces d'eau douce et d'eau salée à cause des différentes nappes d'eau. Deux espèces sont arctiques (*Lycodes pallidus* et *Liparis gibbus*) et nouvelles pour la région de l'estuaire et du golfe St-Laurent. De plus, 238 espèces d'invertébrés ont été identifiés jusqu'à ce jour. Parmi ces espèces on compte 112 Crustacés, 47 Mollusques, 12 Cnidaires, 34 Annélides polychètes, 22 Echinodermes et 11 espèces d'autre taxa. A l'exception de 9 espèces planctoniques, toutes les autres sont benthiques et proviennent principalement des étages bathyal et circalittoral (Drainville et al. 1978).

Matériel et Méthode

Les morues provenaient de la partie supérieure de l'estuaire du Saguenay (Figure 2). Elles furent capturées de janvier 1975 à février 1977. Sur un total de 1 222 spécimens, il y avait 90 immatures et 1 132 adultes répartis en 426 mâles et 706 femelles. Nous avons utilisé des filets maillants au fond dont les mailles étaient de 10, 15 et 20 cm. L'échantillonnage s'est effectué à 50 m de profondeur en hiver et à 200 m en été. Les mesures furent prises immédiatement après la capture.

Nous avons utilisé les otolithes pour la lecture de l'âge. Ces structures étaient cassées en deux, au centre, montées sur lame, colorées à l'alizarine et lues au moyen d'un projecteur de type Nikon. Nous avons employé une machine pour des coupes minces utilisées pour les roches de Fugram Laboratories (modèle 105). L'interprétation des âges était parfois difficile dû à la présence de zones hyalines secondaires et à des zones d'hiver indistinctes. Les otolithes (Figure 3) répondent à la description de Hansen (1949), Otterbach (1954) et Patriquin (1967) et semblent caractéristiques des popu-

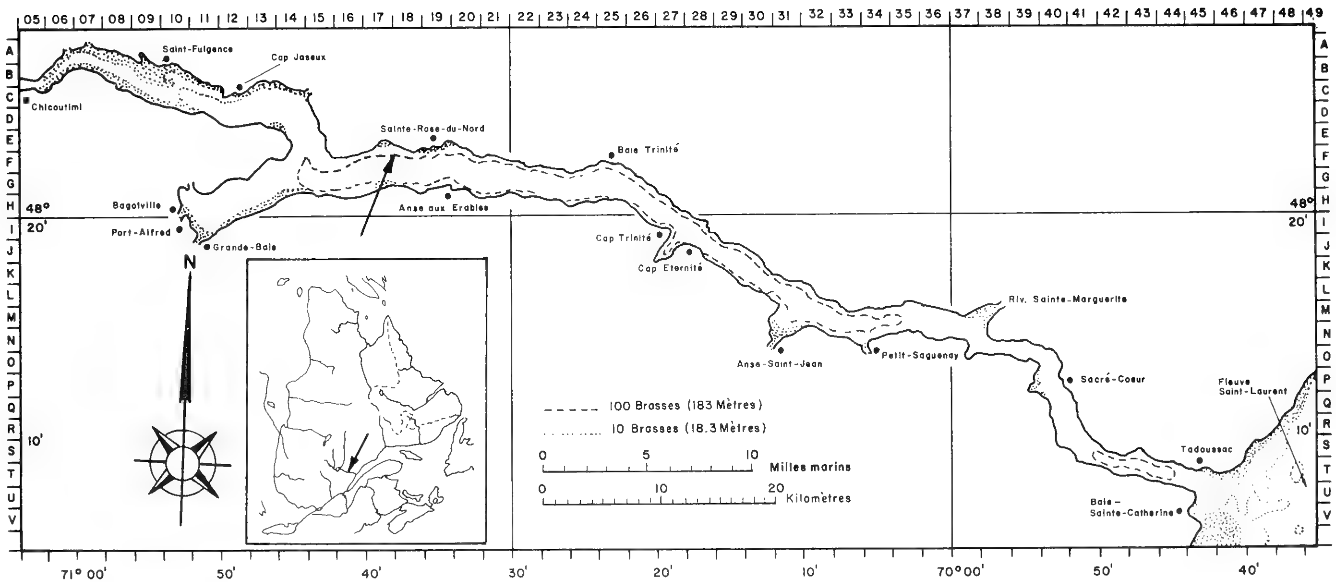

FIGURE 2. Localisation des captures des morues du Saguenay. La flèche indique l'endroit précis.

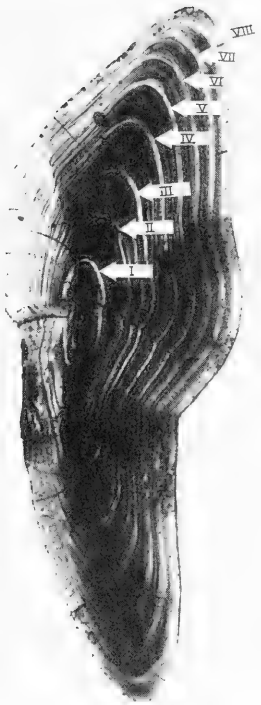

FIGURE 3. Otolithe d'une morue adulte femelle capturée le 27 janvier 1975. Ce poisson appartenait au groupe d'âge VIII, mesurait 629 mm et avait un poids de 2152 g.

lations non-migratoires. Les groupes d'âge correspondent à l'âge réel des poissons; cela a été confirmé par des histogrammes de fréquence et par rétrocalcul. La formation de l'annulus a lieu pour la majorité des spécimens en mars.

Pour faciliter l'étude de la croissance, une équation de régression entre la longueur totale (LT) et le rayon de l'otolithe agrandi 14 fois (RO) fut calculé. Cela nous a permis de préciser la croissance annuelle par rétrocalcul pour les âges I et II et de déterminer la croissance mensuelle. A partir des données obtenues par la lecture des otolithes, nous avons calculé pour chaque groupe d'âge la moyenne des longueurs ainsi que les intervalles de confiance des valeurs individuelles à un niveau de probabilité d'erreur de 5%.

La relation longueur-poids fut estimée à partir de l'équation log P = log a + n log LT et la condition, $K = \frac{P}{a\ LT^n}$ (LeCren 1951), utilisée pour évaluer l'embonpoint des spécimens au cours de l'année. Nous avons calculé aussi les poids des spécimens à la capture et à la formation de l'annulus. Les sexes furent déterminés par l'examen macroscopique des gonades. Les oeufs de 24 femelles furent comptés un à un.

L'étude des contenus stomacaux a porté sur 876 spécimens. Nous avons utilisé les méthodes d'occurence et de dénombrement telles que décrites par Hynes (1950). La méthode de dénombrement donne le pourcentage de proies appartenant à tel groupe taxonomique par rapport au total des proies mangées par les poissons et la méthode d'occurence, donne le pourcentage de poissons qui ont mangé tel type de proies.

Nous avons utilisé un appareil d'absorption atomique Jarrel-Ash, modèle 82 500 équipé de l'accessoire A-82-731 pour l'analyse du mercure sans flamme (Anonyme 1970). La méthode expérimentale a déjà été décrite par Hatch et Ott (1968). Les produits utilisés contenaient moins de 0,005 ppm de mercure.

Résultats

Croissance en longueur

La droite de régression obtenue entre la longueur totale (LT) et le rayon de l'otolithe (RO) est de la forme:

$$LT = 11{,}21\ RO + 4{,}53 \quad (N = 58)$$

et le coefficient de corrélation "r" entre les deux variables est de 0,87. Un test de "F" effectué sur l'homogénéité des variances a révélé que la valeur 4,53 était différente de zéro (F = 39,9); cette valeur fut donc utilisée pour nos rétrocalculs.

La figure 4 donne les longueurs moyennes obtenues pour les différents groupes d'âge. Il est à noter qu'il n'y a pas de différence significative dans la croissance en longueur chez les deux sexes. Cela été révélé par un test de t. Un certain nombre de spécimens demeurent immature jusqu'à l'âge de XII ans. Pour les groupes d'âge III à V, les immatures ont une croissance moyenne inférieure (30 mm), aux adultes mais à partir de six ans, la croissance de ces derniers est assez semblable aux adultes.

La croissance mensuelle calculée par rétrocalcul montre que les morues du Saguenay croissent très rapidement de mai à août mais qu'elles régressent de septembre à février. Cette régression est en moyenne de 25 mm (Figure 5) annuellement.

Croissance en poids

Le tableau 1 donne la croissance en poids des morues adultes et immatures du Saguenay. Pour un même groupe d'âge, les immatures ont des poids inférieurs aux adultes. Pour évaluer la croissance annuelle, nous avons utilisé les poids obtenus à partir de la relation longueur-poids; ces poids sont inférieurs à ceux observés, mais ils donnent une meilleure re-

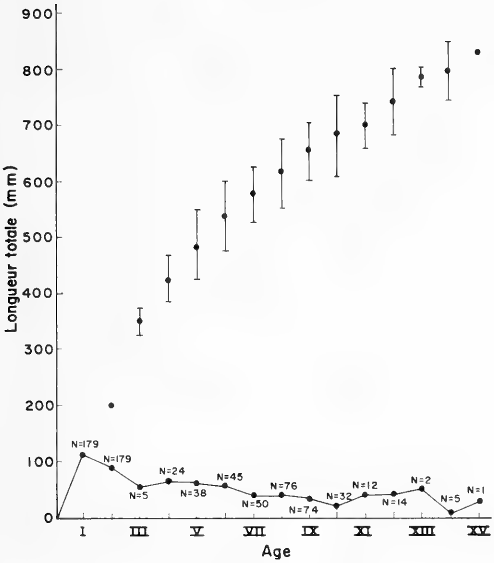

FIGURE 4. Croissance en longueur totale des morues adultes du Saguenay. La courbe du bas indique l'accroissement moyen annuel et les lignes verticales situées de part et d'autre des points représentent l'écart-type. Les longueurs aux âges I et II ont été obtenues par rétrocalcul. N indique le nombre de spécimens.

présentation puisqu'ils dérivent de la longueur totale à la formation de l'annulus.

La relation longueur-poids s'établit suivant l'équation:

$$\log P = 3{,}0374 \log LT - 5{,}1513$$

pour les adultes et il n'y a pas de différence entre les sexes ($P < 0{,}05$). Par contre, cette relation diffère de celle obtenue avec les immatures:

$$\log P = 2{,}3297 \log LT - 3{,}2289$$

puisqu'une analyse de covariance a révélé que la position des deux droites était différente.

La pente de la droite des adultes ne différait pas de 3, mais elle est statistiquement différente chez les immatures ($P < 0{,}05$). Ces derniers sont donc élancés quand ils sont immatures, mais ils deviennent de plus en plus trapus lorsqu'ils atteignent la maturité. D'ailleurs, le tableau 1 indique bien qu'ils ont toujours des poids inférieurs aux adultes, pour le même groupe d'âge et la même taille.

La condition relative des morues mâles et femelles est plutôt constante au cours de l'année. Le rapport hépatosomatique moyen chez les femelles était de 5,3 (3,4 à 7,5) et chez les mâles de 4,0 avec des extrêmes de 2,9 à 5,0.

Reproduction

La morue du Saguenay atteint la maturité sexuelle à l'âge de quatre ans et la figure 6 illustre les proportions suivant les différents groupes d'âge. Dans la population entière, la répartition des sexes était de 0,72 mâle: 1 femelle. Au cours de l'année, nous avons capturé moins de mâles sauf pour les mois d'août et septembre, avant le début de la période de reproduction. Suivant l'âge, le rapport des sexes était de 1: 1 à quatre ans et par suite le nombre de mâles était toujours inférieur à celui des femelles. A partir de treize ans, les proportions changent, mais le nombre des captures n'est pas très élevé.

Le nombre d'oeufs augmente avec la taille et le poids des poissons (Tableau 2). La relation entre le nombre d'oeufs (Y) et le poids (PT) des morues est de la forme:

$$Y = -2{,}3 \times 10^5 + 379{,}4\ PT \quad (r = 0{,}85 \text{ et } N = 24)$$

et entre le nombre d'oeufs (N) et la longueur totale (LT), on obtient:

$$Y = -1{,}7 \times 10^6 + 4092\ LT \quad (r = 0{,}6)$$

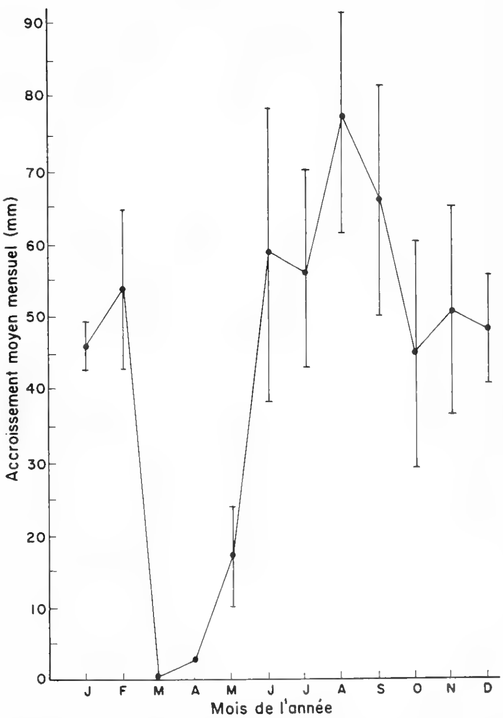

FIGURE 5. Accroissement mensuel des morues du Saguenay. Les lignes verticales représentent l'écart-type.

TABLEAU 1. Croissance en poids des morues du Saguenay.

	Immatures					Matures				
Âge	N	$\overline{P}$	$\overline{PR}$	Extrêmes	S	N	$\overline{P}$	$\overline{PR}$	Extrêmes	S
III	11	324	413	138-482	113	5	402	390	297-513	79
IV	23	540	657	296-1130	218	24	715	660	174-1134	261
V	12	812	900	255-1304	227	38	1472	1002	364-2466	510
VI	5	1518	1399	751-1984	491	45	1566	1398	886-3359	473
VII	2	1099	1006	1035-1162	90	50	1857	1710	978-3572	567
VIII	2	1502	1547	1417-1586	119	76	2271	2097	992-5187	771
IX	4	2270	1962	1474-2736	573	74	2527	2504	1133-4777	777
X	2	2151	1973	1644-2658	717	41	2584	2595	1375-5187	853
XI	1	3629	3056	—	—	12	3185	3093	2388-3856	545
XII	2	3689	3179	3402-3976	405	14	3669	3676	2382-5443	1059
XIII						2	3992	4359	3674-4310	450
XIV						6	4605	4393	3061-6364	730
XV						2	4693	4957	4252-5134	624

N = nombre de spécimens
$\overline{P}$ = poids moyens en grammes
S = écart-type
$\overline{PR}$ = poids à partir de l'équation log P = 3,0374 log LT − 5,1513 pour les adultes et log P = 2,3297 log LT − 3,2289 pour les immatures

Le diamètre moyen après fixation au formol était de 0,72 mm avec des extrêmes de 0,5 à 1,0 mm.

La période de reproduction commence en novembre pour se terminer en mars. Le rapport gonosomatique moyen pour cette période était de 3,2 pour les femelles avec des extrêmes de 1 à 16,7 et de 4,2 pour les mâles (0,3 à 12,1).

Régime alimentaire

Le tableau 3 donne les résultats des deux méthodes utilisées pour l'étude des contenus stomacaux. La morue a un régime varié: crevettes, poissons, gammares, mollusques, etc. On constate aussi qu'en plus des poissons de fond, elle se nourrit de poissons qui vivent plutôt en surface, comme l'éperlan et l'épinoche.

L'importance relative des différents groupes d'organismes ingérés par ce poisson au cours de l'année est illustré à la figure 7. Les crustacés occupent le premier rang (70,5%), suivis des poissons (24,5%), des débris organiques (3,5%), d'autres débris (1,0%) et de mollusques (0,5%). En pratique, ce sont les poissons et les crustacés qui constituent le menu de la morue. D'avril à août, les crustacés prédominent; ils représentent 88% du régime alimentaire, tandis que les poissons diminuent pour la même période, ne représentant que 9%.

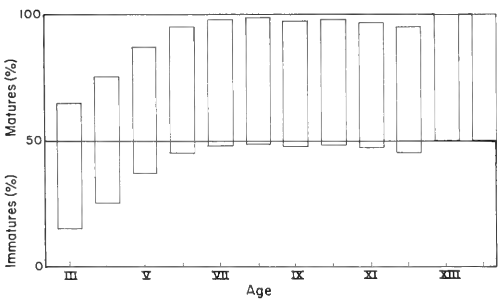

FIGURE 6. Pourcentage de morues immatures et adultes en fonction de l'âge au Saguenay.

La figure 8 illustre la fréquence des organismes et la densité des organismes présents dans les estomacs. Il y a en moyenne 15% des estomacs qui sont vides au cours de l'année, et le nombre moyen d'organismes est de 2,8 par estomac au cours de la même période. Il n'y a pas de période de jeûne hivernal comme chez les poissons d'eau douce.

Le pourcentage de remplissage des estomacs varie de 46% à 67% au cours de l'année avec une moyenne de 57% pour l'année. Nous avons noté que l'ingestion des aliments était d'une certaine façon sélective, en ce sens que lorsqu'il y avait beaucoup de crevettes dans un estomac, il n'y avait presque pas de poissons et vice-versa.

Enfin, les plus petites morues se nourrissaient de petits gammares et de petites crevettes tandis que celles de plus grande taille mangeaient des plus gros poissons et des plus grosses crevettes. Il y a donc une corrélation positive entre les tailles des morues et la dimension de leur proie.

Mercure

L'analyse des muscles de deux spécimens a donné 0,30 μg Hg/g et 4,20 μg Hg/g. Ces poissons mesuraient respectivement 580 et 760 mm de longueur.

TABLEAU 2. Fécondité des morues du Saguenay.

LT	PT	PG	NO	DO
497	1303	130	390 203	0,65
515	1786	206	831 201	0,56
521	1346	120	331 095	0,60
533	1481	120	261 122	0,65
546	1672	160	561 110	0,80
565	1980	170	476 000	0,60
570	1626	100	631 434	0,67
591	2027	140	287 576	0,75
610	2119	164	841 003	0,88
640	2310	269	1 008 001	0,67
645	2500	230	782 032	0,67
652	2268	213	810 666	0,65
686	2721	201	723 031	0,55
699	3359	170	595 051	0,50
711	1375	489	1 221 543	0,60
715	3423	876	1 630 481	0,56
715	1786	205	831 201	0,66
737	4167	733	1 204 214	0,85
755	5216	1134	1 701 052	0,85
775	4052	531	1 062 041	0,85
794	4366	911	2 171 286	0,85
806	4680	623	2 242 822	0,85
813	5103	453	1 020 375	0,90
857	5422	992	1 785 603	1,00

LT = longueur totale en mm
PT = poids total en g
PG = poids des gonades
NO = nombre d'oeufs
DO = diamètre des oeufs

Discussion

Croissance

La croissance annuelle de la morue varie d'un endroit à l'autre et, dans bien des cas, à l'intérieur d'un même secteur (Leim et Scott 1972). En général, les morues du Saguenay ont une croissance moyenne qui se rapproche des poissons du St-Laurent et du Labrador. La température de l'eau qui est typique des régions arctiques (Drainville 1968) et le milieu qui est un des plus pollués des rivières canadiennes (Loring 1975), ne semblent pas affecter la croissance de ces poissons.

La croissance mensuelle que nous avons établie par rétrocalcul à partir des otolithes montre qu'il y a régression au cours de l'automne et de l'hiver chez ce poisson. Ce phénomène avait déjà été démontré que chez quelques poissons d'eau douce comme le *Catostomus commersoni* (Lalancette 1976; Eschmeyer and Crowe 1955) et chez *Salvelinus fontinalis* (R. Lejeune 1956. Rapport de la station biologique du Parc des Laurentides pour la saison 1955-1956. Ministère de la Chasse et des Pêcheries, Québec, Ms.). Mais c'est la première fois qu'une régression en longueur est observée chez un poisson marin. Nous serions donc en

TABLEAU 3. Composition du régime alimentaire de la morue du Saguenay.

Items	Occurence N	Occurence %	Dénombrement N*	Dénombrement %
Crustacés				
Crangon septemspinosa	65	7,4	125	3,7
Gammaracanthus loricatus	22	2,5	43	1,3
Gammarus sp.	25	2,8	185	5,6
Gammarus setosus	29	3,3	665	20,0
Lebeus polaris	227	25,9	503	15,1
Mysis stenolepis	14	1,6	23	0,6
Pandalus borealis	319	36,4	686	20,6
Pandalus montagui	43	4,9	65	1,9
Slerocrangon boreas	40	4,6	47	1,4
Poissons				
Aloso pseudoharengus	1	0,1	1	0,03
Artediellus atlanticus	30	3,4	51	1,5
Careproctus sp.	2	0,2	2	0,06
Gadus morhua	29	2,9	52	1,5
Gasterosteus aculeatus	16	1,8	33	0,9
Hippoglossoides platessoides	3	0,3	3	0,09
Lycodes sp.	210	23,9	339	10,2
Osmerus mordax	26	2,9	52	1,5
Poissons non identifiés	94	10,7	141	4,2
Mollusques				
Buccinum sp.	1	0,4	5	0,1
Bathypolypus arcticus	4	0,1	1	0,03
Mya sp.	3	0,3	3	0,09
Oeufs de buccin	4	0,4	—	—
Polychète	1	0,1	1	0,03
Cailloux	26	2,9	48	1,4
Débris végétaux	5	0,6	—	—
Débris non identifiés	40	4,5	—	—
Estomacs vides	139	15,8	—	—

N : nombre d'estomacs; N* : nombre total d'organismes

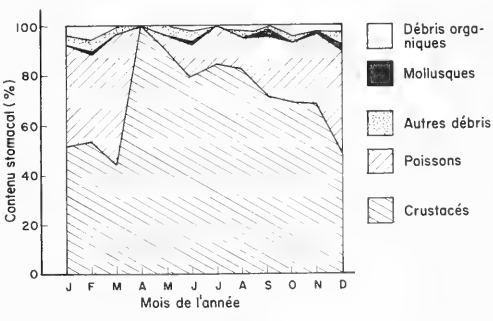

FIGURE 7. Importance relative (%) des différents groupes d'organismes présents dans les estomacs des morues du Saguenay au cours de l'année.

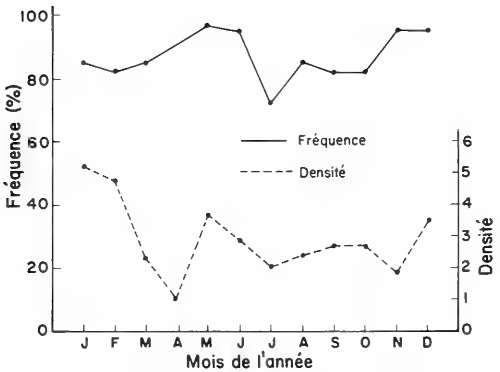

FIGURE 8. Fréquence et densité des organismes présents dans les estomacs des morues du Saguenay.

présence d'un phénomène général qui, dans ce cas-ci, correspondrait *grosso modo* à la période de reproduction chez les adultes.

D'ailleurs, bien qu'on considère habituellement les profondeurs marines comme des milieux stables et à l'abri des variations cycliques, on a pu mettre en évidence des rythmes dans les phénomènes de reproduction de plusieurs invertébrés (Menzies et al. 1973). Plusieurs auteurs (Murray et Hjart 1912; Gilbert et Hubbs 1920; Farran 1924) ont mis en évidence des marques de croissance périodique sur des poissons de profondeurs. Enfin, Rannou et Thiriot-Quievreux (1974) ont dénombré des anneaux concentriques sur les otolithes de *Coryphaenoides guentheri*, un gadiforme, semblables à celles des poissons des zones photiques. Ces marques de croissance se retrouvent chez les morues adultes et immatures du Saguenay. On peut supposer l'existence de rythmes biologiques cycliques synchronisés avec celui des adultes. Ainsi, Malservisi (1968) a démontré chez les perchaudes (*Perca flavescens*) immatures que la gamétogène présentait une activité cyclique saisonnière similaire à celle des adultes.

Si on tient compte de la longueur, les poids des morues du Saguenay sont comparables à ceux des autres populations. Ainsi une morue de 700 mm au Saguenay pèse 3056 g, au lac Ogac, 2994 g (Patriquin, 1967), au Labrador 3220 g (May 1966) et à l'ouest du Groenland 3039 g (Ruivo 1956). D'ailleurs leur taux de croissance représenté par l'exposant de la longueur-poids (Pageau 1967) indique bien que ces poissons ne sont ni plus maigres ni plus gras que ceux de ces populations.

Les calculs que nous avons effectués sur le rapport gonosomatique, le rapport hépatosomatique et la condition de ces poissons sont difficiles à interpréter à cause de la période de reproduction qui s'étend sur cinq mois de l'année. Nous avons obtenu de grandes variations individuelles pour chacun de ces paramètres, mais dans l'ensemble, on peut dire qu'ils demeurent à peu près constants pendant toute l'année.

Reproduction

Nous sommes en présence d'une population de morues qui vit et se reproduit au Saguenay. La capture de spécimens sur douze mois de l'année et l'examen des gonades le confirment. De plus, nous en avons trouvé des jeunes (40-100 mm) dans les contenus stomacaux et, Able (1978) a identifié des larves de ces poissons dans le fjord du Saguenay non loin du St-Laurent. Toutefois, il n'est pas impossible qu'il y ait des migrations de morues en provenance du fleuve St-Laurent. La présence d'éperlans, un poisson de surface, dans les contenus stomacaux indique bien que la morue peut supporter des salinités assez faibles et ainsi franchir le seuil de l'embouchure du fleuve.

Il y a 50% de la population autant chez les mâles que chez les femelles qui atteint la maturité sexuelle à quatre ans. La morue mesure à cet âge 421 mm, ce qui est assez près des données de Minet (1978) pour le nord-est du golfe St-Laurent (488 mm) pour l'âge de cinq ans. Les morues du Saguenay deviennent donc matures une année avant celles du golfe. Cela semble assez curieux parce que la température des eaux du Saguenay sont un peu plus froides que celles du St-Laurent. Toutefois les migrations et les déplacements font qu'elles ne demeurent probablement pas toujours dans les eaux les plus froides du Saguenay. Enfin, le pourcentage d'immatures aux différents âges correspond vraisemblablement à des spécimens qui ne fraient pas chaque année.

Le diamètre moyen des oeufs des morues du Saguenay est beaucoup plus petit que celui des autres populations de morues vivant en d'autres endroits. Les diamètres moyens rapportés varient de 1,12 à 1,65 mm (Rass 1936; McKenzie 1940; Dannevig 1919; Patriquin 1967). Ces auteurs ont mesuré les oeufs dans l'eau en tenant compte du développement de la membrane de fécondation. Au Saguenay, le diamètre des oeufs des morues du Saguenay est sous-estimé parce qu'ils ont été mesurés après avoir séjourné dans le formol.

Le nombre d'oeufs de morues de notre échantillon est comparable à celui des autres populations. Ainsi un poisson de 700 mm a en moyenne 1 164 400 oeufs au Saguenay, 1 023 847 oeufs au Labrador (May 1967), 957 756 oeufs dans le Golfe du St-Laurent (Powles 1958) et 887 536 oeufs à Terreneuve (Pinhorn 1969). Le coefficient de corrélation entre la fécondité et le poids est supérieur à celui de la fécondité et de la longueur. C'est surprenant parce que la longueur est plus constante que le poids. Bien que ce dernier varie davantage avec les saisons, c'est lui qui est à la base de

la production d'oeufs et non pas la longueur. Ici, ce n'est pas important parce que les morues ont été capturées dans la même saison et au même stage de maturité. May (1967) a également trouvé que les coefficients de corrélation entre la fécondité et le poids (r = 0,86) étaient supérieur à celui de la fécondité et de la longueur (r = 0,84).

La période de reproduction qui peut sembler assez longue est conforme à celle des populations de l'Est et de l'Ouest de l'océan Atlantique, c'est-à-dire de décembre à juin (Wise 1961).

Régime alimentaire

La grande variété d'espèces d'organismes qui compose le régime alimentaire de la morue montre qu'elle peut coloniser un grand nombre d'habitats. C'est ce qui explique sa grande répartition dans le monde. Cela est conforme à ce que les autres chercheurs ont trouvé dans les estomacs de morue (Brunel 1972; Patriquin 1967; et Kohler et Fitzgerald 1969).

Comme on l'a mentionné antérieurement, nos résultats nous amènent à conclure que la morue préfère soit les crevettes ou soit les poissons. Elle se nourrit rarement en quantité égale de poissons et de crevettes en même temps. Cela s'explique à notre avis par la répartition spatiale différente des crustacés et des poissons ou par une préférence des morues pour l'une ou l'autre catégorie de nourriture. Ou faudrait-il conclure que le volume des organismes ingérés est plus important que les organismes eux-mêmes? Il est sûr que la morue recherche activement les crevettes. La pêche à la crevette au moyen de casier près de nos filets augmentait le nombre des captures de morues.

Comme Patriquin (1967), nous avons remarqué qu'il y avait du cannibalisme. Au Saguenay, il représente 10% de tous les poissons trouvés dans les contenus stomacaux. Ce phénomène a sûrement un impact négatif sur la population qui est restreinte. Malgré les efforts de pêche déployés (cinq filets maillants pêchant 24 heures par jour), nous ne prenions en moyenne que 8 morues par semaine.

Enfin la présence d'éperlans dans les contenus stomacaux indique que la morue effectue des migrations verticales vers la surface, qu'elle peut supporter des salinités de 4 à 10 ‰ et qu'elle peut franchir le seuil à l'embouchure du fleuve St-Laurent.

Mercure

Les normes gouvernementales canadiennes spécifient une quantité de 0,05 μg de Hg comme valeur acceptable pour la consommation humaine. Cette valeur correspond à la quantité de mercure qu'une personne élimine en une semaine, ou encore à la consommation d'environ 1 kg de poissons contenant 0,5 mg de mercure durant la même période, sans présenter de danger pour la santé.

Le contenu en mercure de trois crevettes (*Pandalus borealis*) du fjord du Saguenay donne une concentration moyenne de 2,20 μg Hg/g (Lebrun et Lalancette 1979) et l'analyse des sédiments de ce même fjord révèle une concentration en mercure de 2,98 ppm (Loring 1975). Il n'est donc pas surprenant que la morue qui consomme principalement des crevettes soit contaminée par cet élément et impropre à la consommation humaine.

Remerciements

Nous tenons à remercier M. Fernand Durand qui a capturé les spécimens. Cette étude a pu être réalisée grâce à une subvention de la Fondation de l'Université du Québec à Chicoutimi et du ministère de l'Éducation du Québec.

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Dispersal and Home Range of Striped Skunks, *Mephitis mephitis*, in an Area of Population Reduction in Southern Alberta

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Dispersal and home range of 16 juvenile Striped Skunks (*Mephitis mephitis*) in an area of population reduction and 12 skunks outside the control area in southern Alberta were minimal. Mean straight line movement was 3.0 km. One juvenile female dispersed 9.7 km. Average home range of skunks was 2.7 km². We believe minimum dispersals and home ranges were related more to population reduction than to landscape barriers.

Key Words: Striped Skunks, *Mephitis mephitis*, Alberta, dispersal, home range, population reduction.

Extensive dispersals of some mammals that transmit rabies have been documented. Two female Red Foxes (*Vulpes vulpes*) migrated 100 and 140 km in southern Jutland (Jensen 1969) and an exceptional movement of 392 km by a Red Fox was noted by Ables (1965). Andersen (1981) found a juvenile Striped Skunk (*Mephitis mephitis*) dispersed 70 km in two months in Alberta.

Dispersal probably plays an important role in the spread of rabies. Artois and Andral (1980) suggested the dispersal of foxes in France is of greater significance to the seasonal spread of rabies than to its prevalence in an area. Rabies may be perpetuated between epizootics by extensive movements of infected individuals (Storm and Verts 1966). Johnson and Beauregard (1969) found a rise in the incidence of rabies in Ontario during late summer and fall associated with the dispersal and reproductive maturation of juvenile male red foxes.

In Alberta, juvenile Striped Skunks disperse between July and November (Bjorge 1977; Gunson and Bjorge 1979, Andersen 1981). A program designed to monitor dispersal was initiated in 1981 in a portion of a 5750-km² area of southern Alberta where 77 cases of rabies in skunks had been diagnosed between December 1979 and June 1981 (Figure 1). A population reduction program for striped skunks has been in effect in this area since January 1980. Dispersal was also monitored in 1982 in a portion of the control area and outside of the zone (Figure 1).

Study Area

The 220-km² study area in 1981 was located in southern Alberta (49°25′N, 112°45′W), in an area of predominantly cereal cropland within the 5750-km² skunk population reduction zone. The gently rolling landscape is traversed with a series of irrigation canals (10-43 m in width, 1–5 m in depth) originating from the Milk Ridge Reservoir. Several coulees up to 70 m deep form potential geographical barriers in the area of population reduction (Figure 1) and one bisects the study area in an E-W direction. Small sloughs and creeks are present. Thirty-six occupied farms, including a large Hutterite colony and several abandoned farmyards, provided denning and resting sites for skunks in the area.

The study area in 1982 was located 40 km east of the 1981 study area and consisted of a 450-km² portion of the population reduction zone and a 130-km² area outside of the zone. The two areas were geographically separated by the Chin Coulee. Topography of both areas was similar to the 1981 study area. Thirteen occupied farms were located in the northern area and 58 in the southern portion.

To avoid confusion between study areas, the 1981 area will be referred to as study area "A", the 1982 area in the population reduction zone as "B", and the 1982 area outside of the population reduction zone as "C".

Materials and Methods

During 9–27 August 1981, eight juvenile striped skunks (four males, four females) were live-trapped, anesthetized with ketamine hydrochloride [4.8–16.7 mg/kg (Rosatte and Hobson 1983)], ear-tagged and radio-collared. Collaring commenced during the first part of August because earlier observations (Bjorge 1977; Andersen 1981) suggested juveniles were independent of their mothers by then. Radio-collars (AVM Instrument Co., California) consisted of an expandable elastic collar (11–16 cm) with a 1-inch whip antenna. The transmitters were SB(2) type, with a lithium 1/2 A battery and an expected life of five months. Signals were monitored with hand-held 4-element yagi antenna, truck-

mounted 18-foot 11-element yagi antenna, and aircraft-mounted (Cessna 172) dual 4-element yagi antenna systems. Skunks were located a minimum of three times per week, weather permitting, by aircraft in the mornings of each search day and again in the afternoon by ground telemetry, to confirm locations, from 9 August to 27 November in study area A. Between 6 July–4 August 1982, 20 juvenile skunks (study area C-12; 6 males, 6 females) (study area B-8; 4 males, 4 females) were collared and released using the same methods and techniques as in study area A. Skunks were monitored from 6 July to 6 December 1982 when they denned up for winter.

Maximum dispersal was determined to be the greatest straight-line distance between the point of collaring and any location. The area of home ranges was calculated by planimeter using the minimum polygon method. Radio locations were taken during the day when skunks were at their resting sites, therefore, home ranges may be slightly smaller than if the locations were taken during the night when the skunks were foraging.

Statistical analysis of the data was accomplished using a simple chi square (Zar 1974).

Results

There were no significant differences in mean dispersals or home range between study areas or sexes. Maximum straight-line dispersal in study area A was 4.0 km by a juvenile male which also had the largest home range (3.0 km², Table 1). Dispersals ranged from 1.6 to 3.2 km for the remaining skunks, with two males moving the greatest distances; 241 locations in total. Home ranges of combined sexes ranged from 0.7 to 3.0 km² (Table 1). Two of the skunks were killed by hunters and farm machinery in late October. Maximum dispersal in study area B was 9.7 km by a juvenile female and 4.2 km by a juvenile male in study area C (Table 1). Maximum distances moved ranged from 0.4 to 9.7 km (mean 3.9) in study area B and 0.5 to 4.2 km (mean 2.7) in study area C; 883 locations in total (Table 1). Home ranges varied from 1.2 to 13.2 km² (mean 4.5) in B and from 0.3 to 3.2 km² (mean 1.4) in C (Table 1). Juvenile males had the largest home ranges in both areas. One juvenile male that disappeared on 8 September 1982, due to a malfunctioning collar was trapped on 11 February 1983, 14.4 km from its point of release. Some of this movement may have been due to breeding activities and it was not included as a fall dispersal. Mean dispersal distance and home range for combined sexes and study areas were 3.0 km and 2.7 km² respectively (Table 1).

During two years (January 1980-82), 1450 skunks (0.13 skunks/km²/yr) were removed as part of the reduction program to control rabies in the 5750-km² area. Population reduction was greater in study area A where 178 skunks (0.54 skunks/km²/yr) were removed during 1.5 years prior to the study period, as opposed to 83 skunks (0.08 skunks/km²/yr) in study area B. Removal methods included trapping (National Live Trap, Conibear 220, 330), shooting, and poisoning with strychnine baits. Control by residents, although not measured, was substantial and was additive to the control program as determined by contact with landowners.

TABLE 1. Dispersal movements and home ranges of radio-collared Striped Skunks in Alberta.

Sex and number	Study area	Min-Max dispersal (km)	Mean dispersal (km)	Min-Max home range (km²)	Mean home range (km²)
M — 4	A[1]	1.6-4.0	2.7	0.7- 3.0	1.8
F — 4	A[1]	1.6-2.4	1.8	1.4- 2.3	1.9
M & F — 8	A[1]	1.6-4.0	2.3	0.7- 3.0	1.8
M — 4	B[2]	2.8-4.0	3.4	1.2-13.2	4.4
F — 4	B[2]	0.4-9.7	4.5	1.9- 7.3	4.6
M & F — 8	B[2]	0.4-9.7	3.9	1.2-13.2	4.5
M — 6	C[3]	1.0-4.2	2.8	1.3- 3.2	2.5
F — 6	C[3]	0.5-1.0	0.2	0.3- 0.5	0.7
M & F — 12[5]	C[3]	0.5-4.2	2.7	0.3- 3.2	1.4
M — 14	ABC[4]	1.0-4.2	3.0	0.7-13.2	2.9
F — 14	ABC[4]	0.4-9.7	2.9	0.3- 7.3	2.5
M & F — 28	ABC[4]	0.4-9.7	3.0	0.3-13.2	2.7

[1]1981 study area (population reduction zone).
[2]1982 south study area (population reduction zone).
[3]1982 north study area (outside of control zone).
[4]combined study areas.
[5]2 M and 2 F that were killed in late July were not included in calculations.

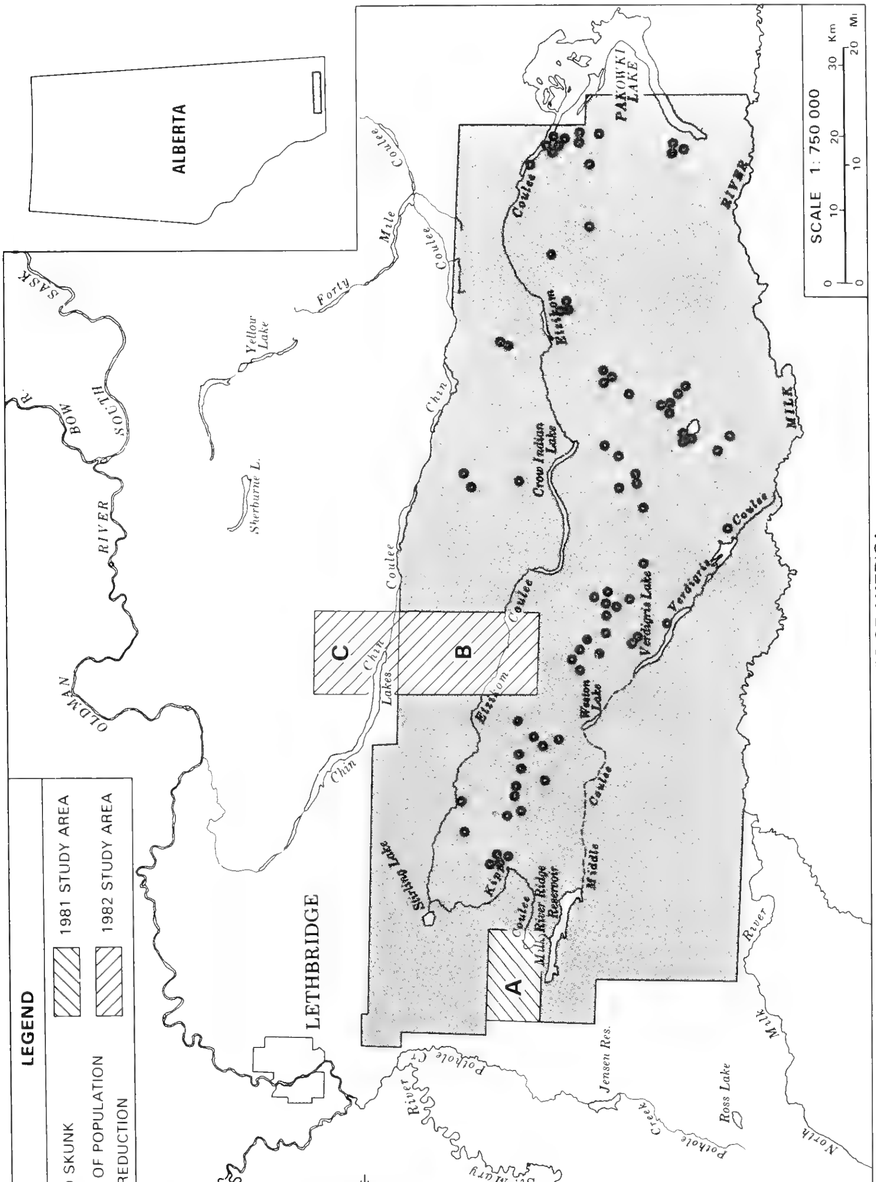

FIGURE 1. Locations of rabid skunks and the intensive study area within and outside of the population reduction zone in southern Alberta.

Discussion

The minimal movements of skunks in this study conflict with extensive movements obtained by other researchers. Andersen (1981) had movements of 70 km by two juvenile female skunks (27 collared) in the prairie of southeastern Alberta. Bjorge et al. (1981) in the parkland of central Alberta had a juvenile female disperse 21.7 km in less than two months; one skunk dispersed 8 km in six days (Bjorge 1977). Sargeant et al. (1982) found one adult male skunk 119 km N.W. of their study area in North Dakota.

Home ranges of skunks in this study (Table 1) compare with those reported by Storm (1972) who had mean home ranges of juvenile males and females of 2.8 and 2.3 km^2 respectively, in Illinois. However, several skunks in southern Alberta and adjacent Saskatchewan, where population reduction was not in effect, had larger home ranges than the above (Andersen 1981).

Wandeler (1980) suggested lakes and mountains function as natural barriers to fox rabies, but he noted rivers are usually crossed where bridges are available. Jennings et al. (1960) in Florida, and Hall (1978) in Tennessee, observed that major water systems restricted the distribution of rabies in terrestrial species. Irrigation canals might have limited movements within our study area; 36 km of canals transected the area. Two skunks were observed crossing irrigation ditches via bridges in study area A. However, skunks in study area C did not cross Chin Coulee into study area B.

Although study area C was not located in the population reduction zone, the density of skunks was probably low due to less available habitat for denning sites. There were only 13 occupied farms in the area as opposed to 36 in study area A and 58 in study area B. Rosatte (1984) found skunks were using occupied farmyards as opposed to other sites for dens in southern Alberta. The lower skunk density in study area C probably resulted in minimal dispersal distances and home ranges of skunks in this area due to lowered competition for denning sites.

We believe that the removal of skunks by population reduction had a greater effect on the observed minimal dispersals than did landscape barriers in study areas A and B. Removal of skunks probably resulted in relatively more available habitat and less competition between skunks, thereby limiting the need for extensive movements. However, the Chin Coulee probably represents a barrier to the movement of skunks between study areas B and C, as none of the 20 radio-collared skunks crossed it. Regardless of whether the population reduction program or physical features limited the dispersal of juvenile skunks, minimal movements may be important in containing the spread of skunk rabies in southern Alberta.

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The Post-spawning Movement and Diel Activity of Rainbow Trout, *Salmo gairdneri,* as Determined By Ultrasonic Tracking in Batchawana Bay, Lake Superior, Ontario

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Post-spawning movement of Rainbow Trout in Batchawana Bay of Lake Superior was examined with ultrasonic tags between 1977 and 1979. Diel activity changes dramatically from a peak between 0600 and 0900 h to an irregular low level between 1600 and 0400 h. Overall diel swimming speed, 1977-1979 inclusive, was 0.22 body lengths per second (BLs^{-1}). Swimming speeds measured between consecutive position fixes was largely, 73–76% of observations, less than 1 BLs^{-1} but swimming speeds of up to 8 BLs^{-1} occurred during the dawn period of peak activity. Males re-entered the spawning stream almost three times more frequently than did females. All fish not re-entering the spawning stream oriented to the shoreline were usually within 150 m of shore and remained in shallow water (< 5 m) until at least mid-June. Most fish, about 90%, travelled north along the shoreline. The choice of direction may have been influenced by wind-generated currents in the bay. Tracking lasted until 1.5 months after spawning and only two fish were lost while apparently leaving Batchawana Bay.

Key Words: Rainbow Trout, *Salmo gairdneri,* ultrasonic tracking, diel activity, movement, behavior, swim speed.

Rainbow Trout (*Salmo gairdneri*) are a popular, prized sport fish in the Great Lakes. However, the movement and diel activity of Steelhead (the form of Rainbow Trout which spends its adult life in the sea or large inland lakes) is, at best, poorly understood.

The stream phase of the life history of Lake Superior Rainbow Trout is reasonably well understood (Kwain 1971; Hassinger et al. 1974) as well as factors influencing migration into the spawning streams (Kwain, unpublished). Rainbow Trout move into spawning streams between mid-March and late April, spawn and move downstream over a period lasting until early summer. Their distribution and movements following spawning are essentially unknown in spite of an intensive sport fishery (MacCrimmon and Gots 1972). To gain a better understanding of post-spawning movement, routes of travel, and diel activity, we tracked individual fish fitted with ultrasonic transmitters. Tracking occurred during the normal period of post-spawning downstream movement and we also tried to determine the post-spawning dispersion patterns of Rainbow Trout either in Batchawana Bay or Lake Superior.

In the Great Lakes, anglers are the major harvesters of Rainbow Trout (Hansen and Stauffer 1971) with most of the effort expended during April-June and September-November. In Stokely Creek, the best known Rainbow Trout stream in Lake Superior, the angler exploitation rate in spring averaged 19%, 1971–75 (Kwain 1981). In both Batchawana Bay and Stokely Creek, angler success drops by at least 50% following the first influx of fish to the spawning stream.

The timing of the downstream migration was examined in 1971 (Figure 1). In that year, peak upstream migration extended from mid-April to mid-May followed by downstream migration extending from mid-May to early July.

In 1969 and 1975, vertical gill nets (1.8 m by 30.5 m composed of mesh sizes ranging from 2.5 to 13.5 cm in 1.25 cm intervals) were set in Batchawana Bay, and tended, to examine vertical distribution of Rainbow Trout following spawning. Only six Rainbow Trout were caught in 1969 and one in 1975, even though 57 and 29 24h sets were made in the respective years.

These efforts coupled with the limited published information indicated that tracking of individual fish was the most productive possible method for understanding post-spawning movement and diel activity.

Methods and Materials

Rainbow Trout intended for tracking were captured, mid-March to late April, within 150 m of the mouth of Stokely Creek, Batchawana Bay, Lake Superior. Stokely Creek was therefore assumed to be their spawning stream. Bottom set gill nets, 7.6 to 10.2 cm stretched mesh, were continuously patrolled and the length of actively fished net, 7.6–91.5 m, was

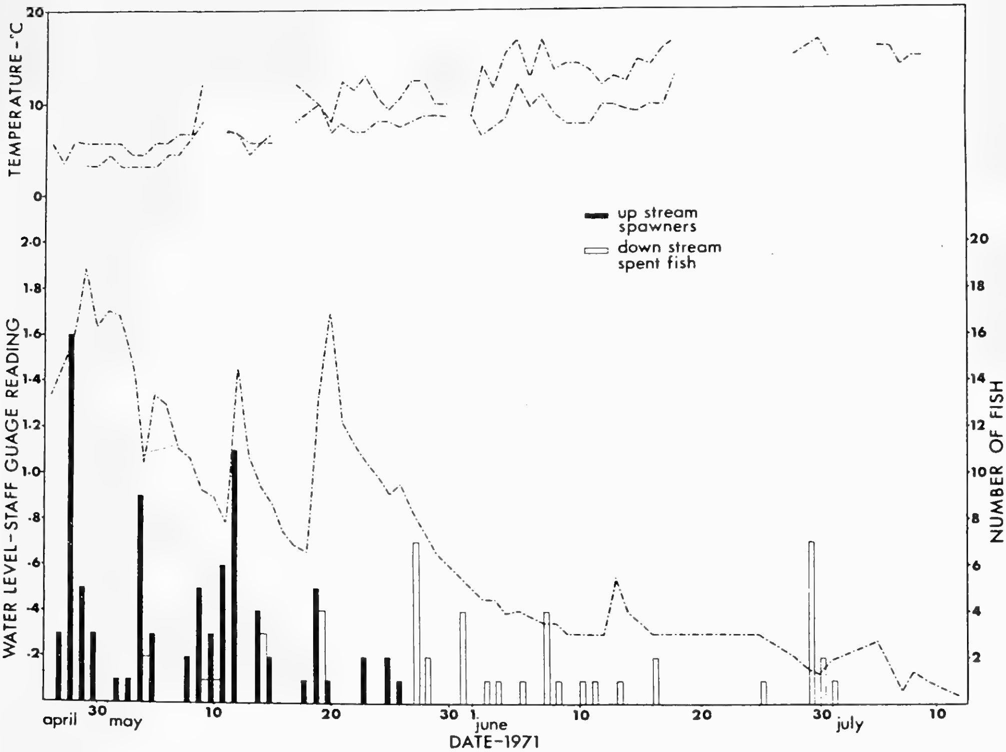

FIGURE 1. Downstream migration of Rainbow Trout from Stokely Creek, Lake Superior, in relation to temperature and stream discharge.

adjusted to control the capture rate. Fish were transported in aerated lake water to holding facilities at the Chippewa River (Department of Fisheries and Oceans) and the Tarentorus Hatchery (Ontario Ministry of Natural Resources). At the Chippewa River, water from the river was continuously pumped through 2000 L fibreglass tanks. At the hatchery, untreated spring water served either outdoor circular ponds (1977, 1978) or indoor 2000 L tanks (1979). Natural photoperiods existed at both sites and temperatures paralleled nearshore temperatures of Batchawana Bay.

Fish were checked on a frequent, irregular basis to determine state of maturity. When either males or females were ripe, they were manually stripped of their reproductive products. Most fish were stripped at least five days prior to release.

A Smith Root model SR69B transmitter was sewn using stainless steel surgical wire onto the dorsal aspect of each fish just anterior to the insertion of the dorsal fin. Tag attachment was completed within one minute and healthy fish were released 5–10 minutes after transmitter attachment. Tracking systems and procedures were similar to those used by Kelso (1976) and Kelso (1978).

Tracking commenced immediately after ice-out in 1977 (2 May), 1978 (8 May), and 1979 (7 May). Generally, a fish was tagged and released on Monday of each week and followed continuously for 2–3 days or until lost, whichever occurred first. Fish were tracked for only several days to enable collecting data from at least two fish per week during the spawning period. If a fish was lost during tracking, another was released. If a fish re-entered the spawning stream, tracking was resumed on re-entrance to Batchawana Bay.

All fish were continuously followed in a 6 m outboard powered boat. The boat was maintained within 50 to 75 m of the tagged fish and all position changes were recorded. When transmitter reception in the nearshore bay was limited by turbulence, tracking was curtailed. All changes in direction of travel were recorded and the position of the change in direction

was determined by triangulation or by a combination of reference to shoreline irregularities and relating depth determined by a BenMar depth recorder to bathmetric charts.

In 1979, 10 fish with transmitters were simultaneously released on 28 May and relocated on each succeeding day until the last individual was lost or, more likely, the transmitter expired. Transmitters lasted about 14 days.

Results

In the spring of 1977, 1978, and 1979, a total of 33 Rainbow Trout were continuously followed (Table 1). Of these, approximately one quarter re-entered the spawning stream. The ratio of males to females in the total sample was 0.8; however, the ratio of males to females for those that re-entered the spawning stream was 2.7.

The longest continuous track was for 3.2 days in 1978 (Table 1). Almost half the tracks were from 24 to 48 h duration. Tracks of shorter duration resulted from transmitter failure, adverse weather or inability to locate the fish, usually after a change in personnel.

The longer tracks (Table 1) were divided into hourly intervals to examine diel activity (Figure 2). Analysis of variance indicated that a significant difference existed among the three years ($P < 0.05$). From Figure 2, it is apparent that swim speeds in body lengths per second (BLs^{-1}) observed in 1977 (mean over 24 h = 0.33 BLs^{-1}) were greater than in the other two years. On the other hand, swim speeds observed during 1978 (mean over 24 h = 0.16) and 1979 (mean over 24 h = 0.19) were not significantly different. Overall swimming speed, all years, for Rainbow Trout was 0.22 BLs^{-1} over a 24 h period.

Although swim speed differed somewhat among years, the diel pattern of movement was similar (Figure 2). The greatest activity occurred at or just after dawn (0600–0900 h) with the exception of a brief predawn period of intense movement in 1978. Swim speeds of up to 2.3 BLs^{-1}, measured over hourly periods, were observed during the dawn period. Rainbow Trout were less active (0.10 to 0.20 BLs^{-1}) between 1600 and 0600 h. If individuals were inactive, it was generally during late afternoon and early evening.

Swimming speeds between position fixes (Figure 3) were determined (a period of continuing movement; may approximate cruising speed) for all fish tracked. There was no significant difference among the three years ($\chi^2 = 24.84$, $P < 0.05$). Rainbow Trout swam between 0.0 and 7.0 BLs^{-1}, with approximately 75% of observations < 1.0 BLs^{-1}. The limited higher swimming speeds usually occurred during the dawn period of high activity.

On release at the mouth of the spawning stream, most fish conformed to the shoreline and usually remained within 150 m of shore (Figure 4). Direct crossings of the bay were rare. On release, most fish spent some limited amount of time, usually less than 4 h, "searching" at the mouth of the Stokely Creek. During tracking, individuals were frequently, approximately 30-40% of position fixes, in water depths < 3 m deep. When in deeper water, Rainbow Trout were most frequently found (by depth recorder and approximation of angle of depression of the hydrophone) in water depths < 10 m irrespective of lake depth. In 1977, approximately half the releases followed the southern shore to the gap which joins Batchawana Bay to Lake Superior. Two fish were lost in the vicinity of this link with Lake Superior. In other years, no fish were observed leaving the bay. Although a few fish followed the southern shore, the majority travelled north with movement conforming to the shoreline.

For each track we determined the frequency of occurrence of turning angle and distance between turns (Figure 5) to indicate localization in movement (generally related to orientation, see Kelso (1976). A 3×3 test of independence using the G test (Sokal and Rohlf 1969) indicated that the variables (year, angle of turn and distance between turns) were not independent ($\chi^2 = 31.03$, $P < 0.05$). In 1977 and 1978, fish followed the shoreline and tended to leave the spawning stream soon after release. In 1979, Rainbow Trout showed a greater affinity for the spawning stream (Table 1) and those that did not re-enter the stream spent considerable time at the stream mouth, reversing their course. On the other hand, angle and distance between turns were related ($\chi^2 = 6.19$, $P < 0.05$). This interrelation reflects the relative minor course adjustment required to conform to the shoreline.

In order to confirm the routes of travel determined from individual tracks, and hopefully to determine whether Rainbow Trout remained residents of Batchawana Bay we simultaneously released 10 fish equipped with transmitters. The dispersal pattern of these fish (Figure 6) was virtually identical to the individuals tracked from 1977 to 1979. Some fish, however, spent up to three days near the spawning stream prior to movement along the northern shore. On the fourteenth day following release, only four fish were found despite a search pattern which covered the entire bay. Swim speed calculated for these fish was 0.07 BLs^{-1}, considerably less than the 0.22 BLs^{-1} calculated for fish continuously observed.

Discussion

We have studied free-ranging Rainbow Trout, although we injected unknown biases by our capture, holding and tagging procedures. In spite of a possible impairment of function in fish (McCleave and Stred

TABLE 1. Tracking data for 33 rainbow trout released and continuously followed, 2 May to 1 June, 1977-1979, Batchawana Bay, Lake Superior. Fish numbers denoted by * re-entered the spawning stream.

Fish No.	Release Date	Fork Length cm	Weight g	Sex	Continuous Track. Time min	No. of Position Changes	Mean Angle of Turn	Mean Distance Between Turns	Mean Time Between Turns min	Total Distance Travelled m	Termination Reason	Mean swim speed (BLs⁻¹) over Track
1977												
1	May 2	50.7	1262	M	2750	13	108	344	212	4475		0.05
2	9	54.0	1516	F	530	4	69	288	133	1150		0.07
3	10	38.3	558	F	1550	17	63	663	91	11263		0.32
4	12	53.1	1443	F	345	4	73	2069	86	8275		0.75
5	16	51.1	1291	?	114	3	26	783	38	2350		0.67
6*	18	54.8	2762	M	1356	62	65	474	22	29400		0.66
7	18	40.0	633	?	—	1	—	—	—	—	Bad Weather	
8*	31	51.1	1291	F	1237	48	60	402	26	19300		0.51
9	June 1	34.2	401	?	2805	7	79	1082	401	7575		0.13
10*	1	37.0	504	M	2992	9	83	819	332	7375		0.11
1978												
1	May 8	45.4	915	F	425	6	87	471	71	2825		0.24
2	8	58.5	1914	F	4603	38	66	434	121	16504		0.10
3	10	68.8	3068	F	65	2	109	400	33	800		0.30
4	10	47.0	1012	M	300	4	37	150	75	601		0.07
5*	15	65.3	2635	F	—	1	—	—	—	—		
6	15	66.4	2767	M	150	13	106	170	12	2214		0.37
7*	16	51.2	1298	M	496	11	36	218	45	2400		0.16
8	16	49.5	1177	F	541	14	96	165	39	2314		0.14
9	17	?		F	—	1	—	—	—	—	Equip. Failure	
9	17	44.3	852	F	—	1	—	—	—	—	Lost	
10	23	?		?	—	1	—	—	—	—	Dead	
11	23	60.0	2060	F	—	0	—	—	—	—	Dead	
12	24	56.3	1712	F	580	7	110	432	83	3026		0.15
1979												
1	May 7	60.5	2110	?	349	11	147	307	32	3375		0.27
2*	8	58.0	1866	M	275	10	121	223	28	2225		0.23
3*	9	57.4	1811	M	337	23	110	202	15	4635		0.40
4	10	52.5	1396	?	—	6	—	—	—	—	Lost	
5	14	40.7	666	?	—	12	77	—	—	—	Lost	
6	14	46.0	951	F	1553	35	85	391	44	13675		0.32
7*	16	48.4	1102	M	342	21	88	257	16	5395		0.54
8*	17	44.4	857	M	291	15	126	267	19	4000		0.52
9*	22	52.0	1358	F	385	16	69	234	24	3750		0.31
10*	23	54.2	1532	M	527	28	100	255	19	7150		0.42
11	24	45.2	903	M	75	4	79	288	19	1150		0.57

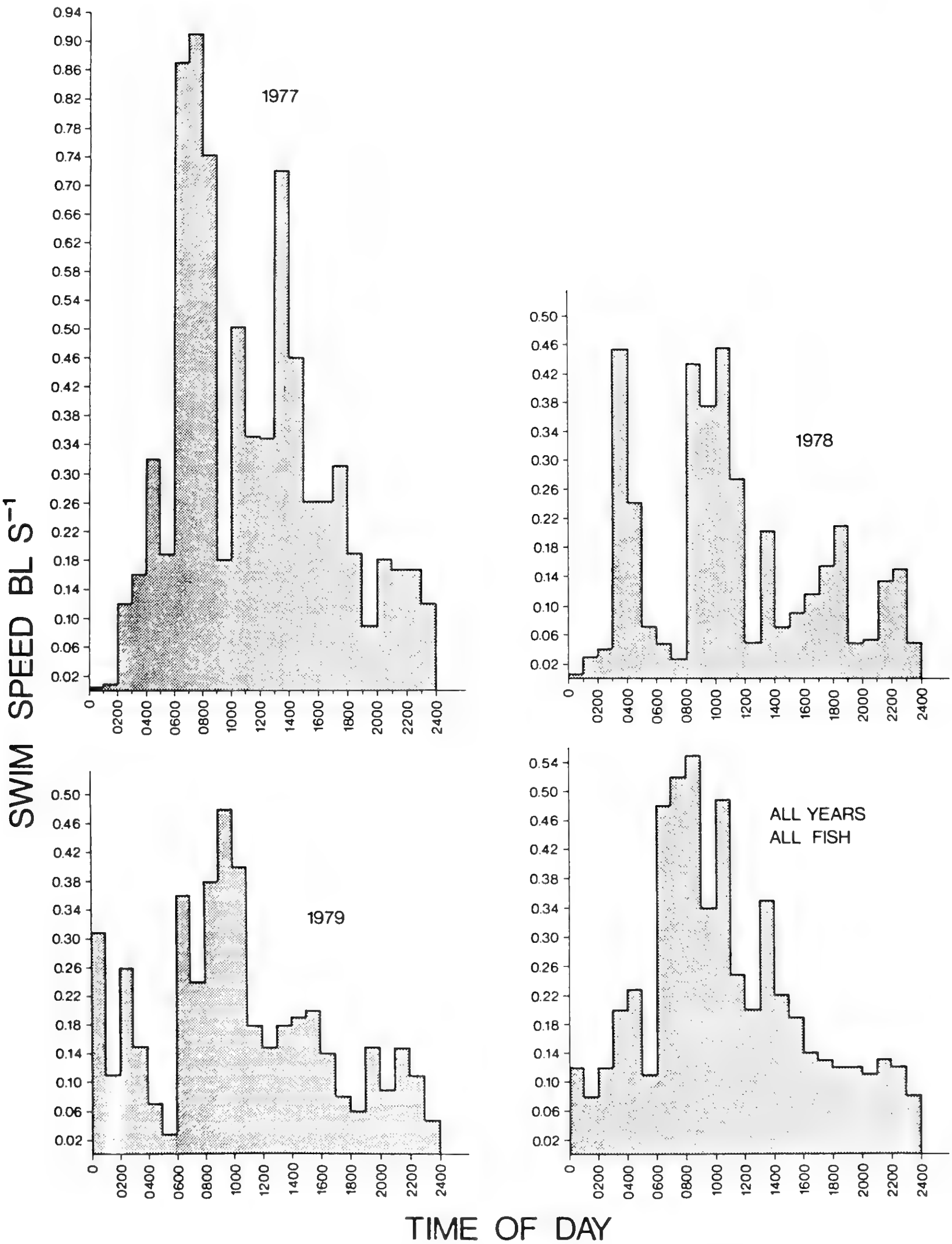

FIGURE 2. Diel activity, in BLs^{-1}, of Rainbow Trout released in the springs of 1977, 1978, 1979, and the composite of all years, Batchawana Bay, Lake Superior.

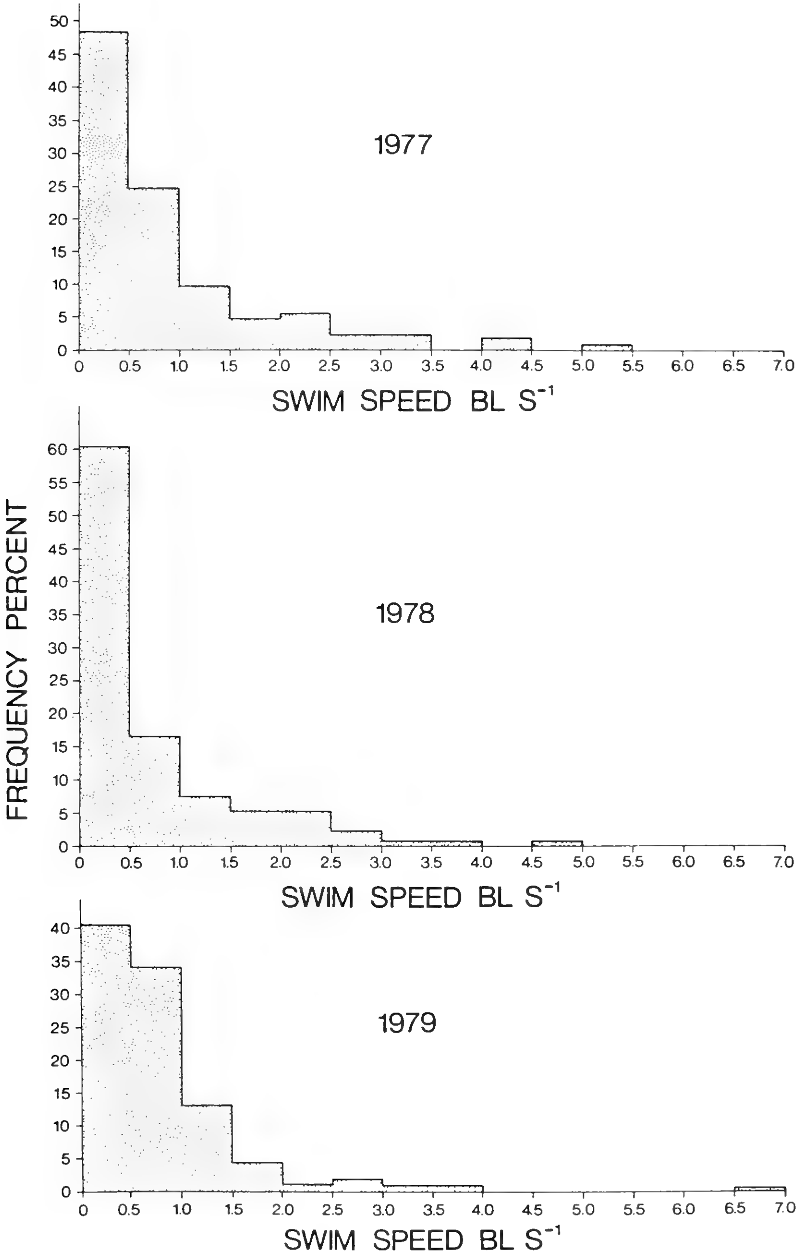

FIGURE 3. Swimming speed of Rainbow Trout in BLs^{-1} determined between position fixes during 1977, 1978, and 1979.

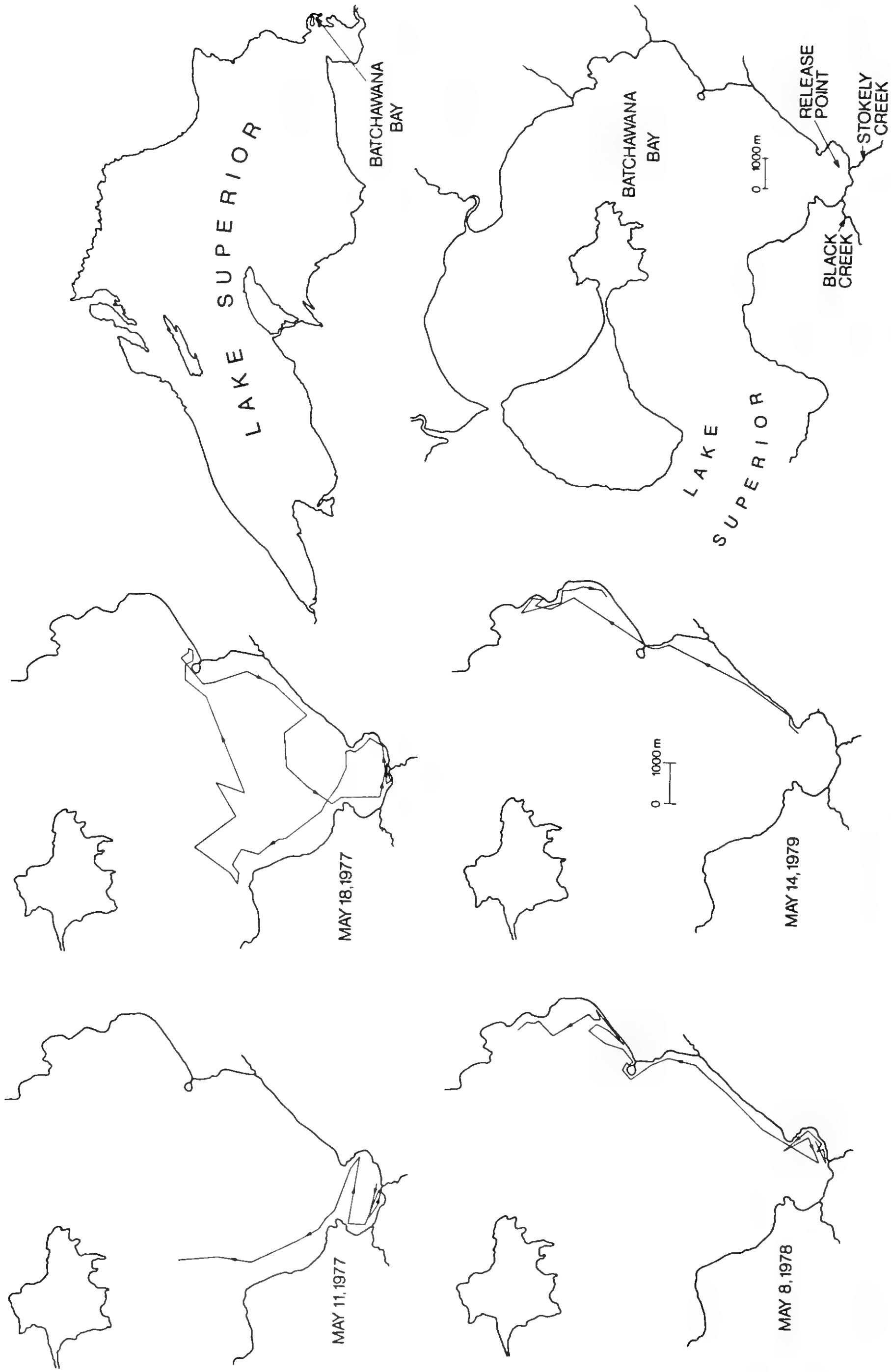

FIGURE 4. Selected tracks of individual Rainbow Trout released in 1977, 1978, and 1979, and the relation of Batchawana Bay to Lake Superior.

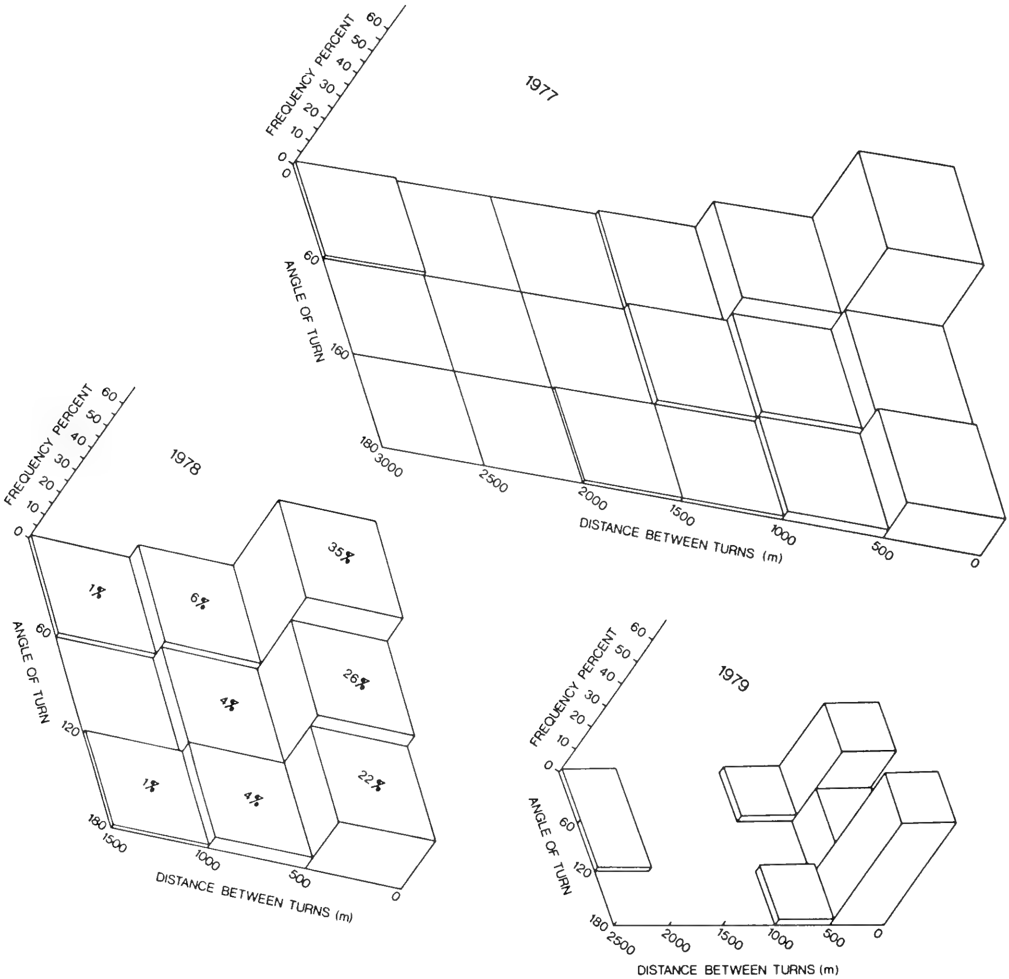

FIGURE 5. The frequency of occurrence in percent of turning angle and distance between turns for Rainbow Trout tracked in 1977, 1978, and 1979.

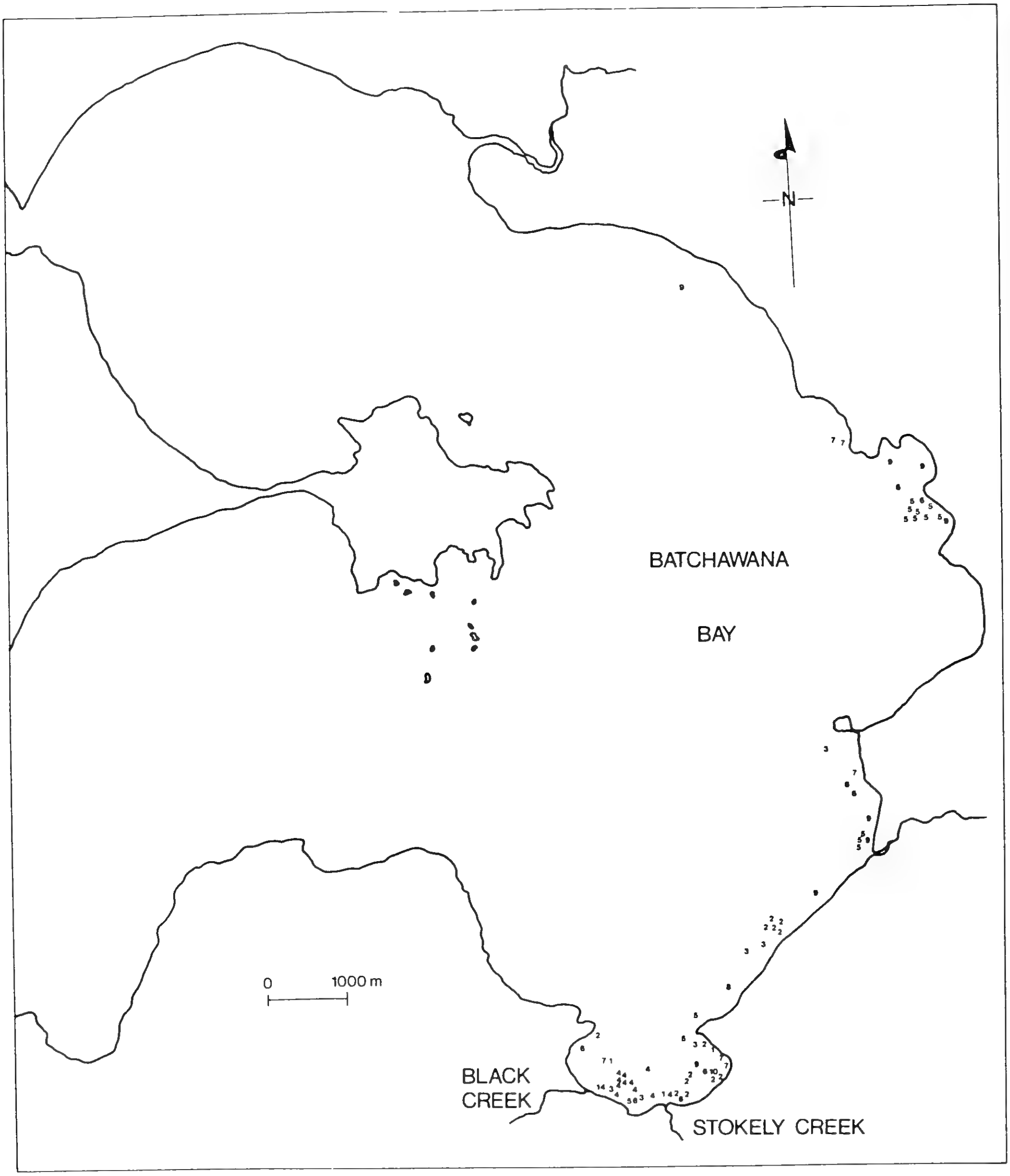

FIGURE 6. Movement of 10 Rainbow Trout released simultaneously on 28 May 1979, and tracked on a daily basis for 14 days, Batchawana Bay, Lake Superior. Numerals from 1 to 10 represent individual fish and the placement of the numeral indicates position on consecutive days.

1975), our technique still provides the best experimental approach to examine natural behavior (Stasko 1971).

Rainbow Trout were most active at and immediately after dawn (Figure 2). Local anglers tend to fish more just after dawn and just before dark (O. Wohlgemuth, Ontario Ministry of Natural Resources, personal communication). Whether this is because of increased success or the angler's time available for fishing is unknown. Our study suggests that the dawn period should be most successful. Most upstream migration during spawning occurs during daylight (Shapovalov and Taft 1954). In Stokely Creek, most upstream movement occurs during the dawn and early morning (Kwain, unpublished data). Further, periods of increased activity in fish can coincide with restricted feeding activity (Kelso 1978). In Rainbow Trout, feeding in young fish is size-selective and feeding activity was highest during the dawn period, 0800 to 1200 h, in an experimental stream (Bisson 1978). Thus, evidence from angler effort, upstream migration during spawning runs and feeding in experimental streams generally coincide with our tracking studies.

Swimming speeds for Rainbow Trout were largely below 1 BLs^{-1} although short term speeds of up to 7 BLs^{-1} were observed. If a 40 cm unconfined fish swam in a linear manner, daily travel would be 3.8 km day^{-1}. This is considerably greater than the 1.2 to 1.6 km day^{-1} estimated by Winter (1976). However, it is obvious from Figures 4, 5, and 6 that travel is influenced at least by shoreline irregularities. The swimming speeds of Rainbow Trout were similar to those of Walleye (Kelso 1978) and Yellow Perch (Kelso 1976) although Rainbow Trout swam at greater rates for short periods (Figure 3). Rainbow Trout of similar size to our experimental animals, 1000 to 1400 g, have maximum sustained swimming speeds between 2.75 and 3 BLs^{-1} (Fry and Cox 1970). The maximum sustained swimming speed is about 12 times greater than the average daily speed but well within the natural range demonstrated by our tracking (Figures 2 and 3).

In Batchawana Bay, Rainbow Trout did not travel great distances from the spawning stream during the month following spawning (Figures 4 and 6). Although Winter's (1976) data are sparse, he found that fish followed the shoreline until they "apparently" found currents after which they were lost and presumed to travel offshore. In Batchawana Bay, fish generally followed the shoreline and, until early June at least, were in water depths of < 5 m.

It is likely that water currents play a role in orientation in addition to the effect observed from the shoreline itself; thus movement along the southerly shore in 1977 could be an orientation into a counterclockwise current generated by easterly winds (Atmospheric Environment Service, Sault Ste. Marie, Ontario) while movement along the northerly shore would be a response to the westerly wind generated clockwise current.

Whether fish using Stokely Creek as a spawning stream remain in Batchawana Bay following spawning is still largely unknown. The data, however, suggest that at least a small proportion of fish do leave the bay and enter the open lake. Kwain tagged 82 Rainbow Trout in Stokely Creek during 1970-75. Twenty-six percent of the releases were recaptured but $< 1\%$ of these were recaptured outside of Batchawana Bay. These data are strongly biased since most angler effort is expended in streams and is confined to the spring fishery. Hansen and Stauffer (1971) indicated that in many instances Rainbow Trout are far ranging following their association with streams and that travel between the interconnecting Great Lakes is not uncommon. Our results may reflect that either duration of contact was too short or fish in Batchawana Bay do not range as freely as other stocks.

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Dr. J. A. McLean, Research Branch, Ontario Ministry of Natural Resources, Maple, Ontario, thoughtfully reviewed a draft of this paper.

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Observations on the Migration, Ecology and Behaviour of Bats at Delta Marsh, Manitoba

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The seasonal abundance, ecology and behaviour of bats was studied at Delta Marsh, Manitoba from 1981 to 1983. Two hundred and thirty-nine bats of four species (*Lasiurus borealis, L. cinereus, Lasionycteris noctivagans* and *Myotis lucifugus*) were captured and bat activity was monitored along transects with microphones to detect species-specific echolocation calls. *L. noctivagans* and *L. cinereus* were permanent summer residents while *L. borealis* moved through the area in the spring and fall and *M. lucifugus* was generally uncommon. The first bats arrived in mid-May and the last left in mid to late September. In the late summer, male *L. borealis* moved through the area later than females. All species fed primarily along a narrow forested ridge rather than over the marsh or Lake Manitoba. Individual *L. cinereus* established feeding territories from which they chased other bats. Lactating female *L. cinereus* and their young roosted in trees in the ridge and although each female fed independently of her young, each family group roosted together for over two weeks after the young were volant.

Key Words: Hoary Bat, Red Bat, Silver Haired Bat, *Lasiurus cinereus, Lasiurus borealis, Lasionycteris noctivagans,* migration, ecology, behaviour.

Little is known regarding the bats of the Canadian prairies and much of the work to date has involved only the collection of individuals from different areas (e.g. Tamsitt 1962). Current technology, however, allows remote monitoring and species identification of bats by their echolocation calls (Fenton and Bell 1981), and using this technique information regarding species abundance, habitat use, community structure, resource partitioning and other ecological and behavioural phenomena can be obtained (e.g. Bell 1980). Although the prairie provinces lack a diverse bat fauna (Banfield 1974), three of the species, *Lasiurus borealis* (the Red Bat), *L. cinereus* (the Hoary Bat) and *Lasionycteris noctivagans* (the Silver Haired Bat), are interesting because of their presumed solitary, tree-roosting habits and migratory behaviour. Relatively little is known regarding even the basic ecology and behaviour of these species. Preliminary data and records in the literature (e.g. Tamsitt 1962; Sealy 1978) indicated that all three bats were present in the Delta Marsh area of Manitoba.

This paper reports information concerning the distribution, seasonal abundance and foraging behaviour and ecology of these three poorly understood species.

Methods and Materials

The study was conducted at the University of Manitoba Field Station, Delta Marsh, Manitoba during August and September 1981 and April through September 1982 and 1983. Delta Marsh, consisting of large open bays, narrow channels and wet meadows, is separated from the southern end of Lake Manitoba by a narrow (ave. 80 m wide) forested dune-ridge (see Mackenzie 1982 for details).

Bats were caught in Tuttle (harp) traps (Tuttle 1974) set along a dirt road running through the south edge of the ridge where trees formed natural tunnels. Individuals were identified, sexed, aged as adults or subadults (young of the year), banded with species-specific coloured split-rings and weighed to the nearest 0.1 g just before release the evening following capture.

Bat activity was assessed in 1982 and 1983 along three transects, each covering the major habitats of the study area; the lake and beach, forested ridge, marsh and meadow. Each transect was approximately 6 km long, took two hours to paddle or walk and was covered at least once a week from the beginning of May to the end of September. Transects were traversed during three times of the night: early (starting 30 min after sunset), middle and late (ending 30 min before sunrise).

Flying bats were monitored along the transects with a QMC mini-bat detector tuned to 35 kHz and a broadband capacitance microphone in conjunction with a zero-crossing period meter and an NLS MS-15 oscilloscope (Simmons et al. 1979). This allowed me to identify each bat to species on the basis of its echolocation call characteristics as detected on the QMC and displayed sonographically (frequency versus time) on the oscilloscope (Figure 1). The characteristics of the calls of each species were determined in

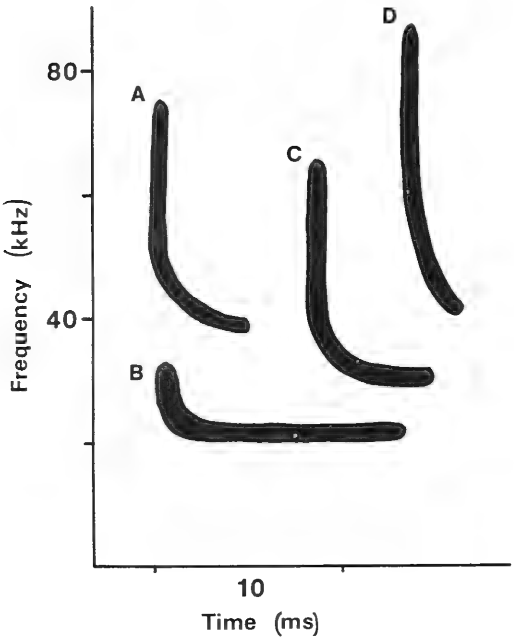

FIGURE 1. Sonographic display of the echolocation calls of bats at Delta Marsh, Manitoba. A) *L. borealis*, B) *L. cinereus*, C) *L. noctivagans*, D) *M. lucifugus*. Often the smooth frequency sweep of *M. lucifugus* calls appears more angular when displayed on an expanded horizontal scale (e.g. see Fenton et al. 1983).

1981 by recording known bats as they were released outside. Calls were recorded on an Ampex tape recorder operated at 76 cm/s through the broadband microphone and analyzed on a Kay 7029A sonograph and a Princeton Applied Research fast Fourier transform real time spectrum analyzer model 4513. Feeding activity for each species was also measured along the transects by counting the number of feeding buzzes, the rapid series of echolocation pulses produced by a bat attempting to catch an insect.

Roosting bats were located in the ridge during the day. Their presence and foraging behaviour were monitored daily at dusk to determine roost stability and duration of residency.

Results

A total of 239 bats were captured in 204 trap nights (Table 1). Capture rates were considerably higher in 1982 (1.08 bats/trap-night; n = 114 trap-nights) than in 1983 (0.48 bats/trap-night; n = 58 trap-nights). In both years, however, captures were most common during July, August and September with a smaller peak in late May and early June. All but two of the May and early June captures were of adult female *L. noctivagans* (n = 19) and *Myotis lucifugus* (the Little Brown Bat) (n = 15). Pregnant Hoary Bats were captured on 4 and 13 June 1982 and 11 June 1983, a roosting individual gave birth on 17 June 1983 and a lactating individual was captured on 1 July 1982. All sex and age classes of each species were captured in the late summer and fall although I found it difficult to age Red Bats and adults and subadults are thus combined (Table 1). Only male Red Bats were captured late in the year (Figure 2) whereas both females and males were present in July and early August. The last capture date for Red and Little Brown Bats was 19 September, for Silver Haired Bats 10 September and for Hoary Bats 3 September.

The echolocation calls of the four species caught at Delta were easily recognizable on the basis of their frequency patterns and durations (Figure 1), and the activity data thus give a much better picture of the presence and abundance of the various species than does trapping. The Silver Haired Bat was the most commonly encountered species followed by Hoaries, Reds and Little Browns in that order (Table 2). However, only Hoary and Silver Haired Bats were present throughout the summer while Red Bats moved through the area in the spring and again in the late summer (Figure 3). Little Brown Bats were not com-

TABLE 1. Summary of bats caught during 1981, 1982 and 1983 at Delta Marsh, Manitoba. Adult and subadult *L. borealis* are combined due to the difficulty in accurately aging them.

		L. borealis	*L. cinereus*	*L. noctivagans*	*M. lucifugus*
	Adult		9	7	4
Male		79			
	Subadult		12	7	7
	Adult		11	25	23
Female		32			
	Subadult		3	7	12
Unknown			1		
Total		111	36	46	46

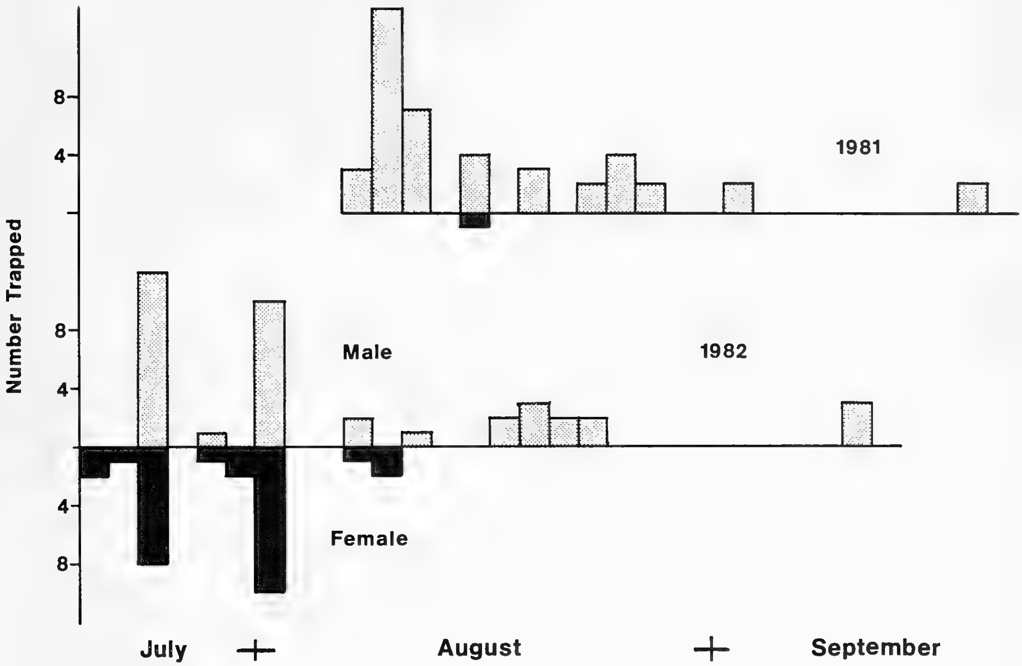

FIGURE 2. The number of male and female *L. borealis* trapped at Delta Marsh, Manitoba during 1981 and 1982.

mon at any time and did not regularly inhabit any of the buildings at or near the field station. A small nursery colony (26 adult females) was located, however, 6 km southeast of the station in the same farmhouse from which Tamsitt (1962) reported a Little Brown colony.

A major influx of Silver Haired Bats occurred in late May and early June, followed shortly after by a smaller peak of Red and Hoary Bats (Figure 3). A more prolonged peak in all species occurred in late July, August and September with a sharp peak in early September associated with mild temperatures. Similar seasonal patterns were noted in 1983 with Silver Haired and Hoary Bats again the most common species. However, as with captures, activity of all species was markedly lower in 1983 than in 1982. Average activity over the summer was 16.3 passes/hour in 1982 (n = 2480 passes) but only 5.2 passes/hour in 1983 (n = 567 passes).

TABLE 2. Total number of bat passes and feeding buzzes counted in 101 transects during 1982 at Delta Marsh, Manitoba.

	Passes	Feeding Buzzes
L. noctivagans	1291	417
L. cinereus	560	65
L. borealis	483	20
M. lucifugus	146	19

Between 70 and 77 percent of the activity of each species in 1982 occurred on either side of the ridge as opposed to over the marsh or meadows. Activity over the marsh only occurred in appreciable amounts in August and September while activity over the meadows was always low. Visual observations of flying bats indicated that they generally flew at or just below tree top level (7–15 m) on the lee side of the ridge, but within 1–3 m of the water over the marsh. All species were active throughout the night from approximately 30 min after sunset.

Individual Hoary Bats were observed on numerous occasions feeding back and forth along 40–50 m routes in the lee of the ridge or around lights on buildings. These bats stayed in the same location for up to 45 min or more and aggressively chased out other bats, both conspecifics and other species. Chases involved audible vocalizations from the attacking bat as it dove from above and behind the intruder, occasionally making contact with it. I could not determine how consistently any one Hoary could

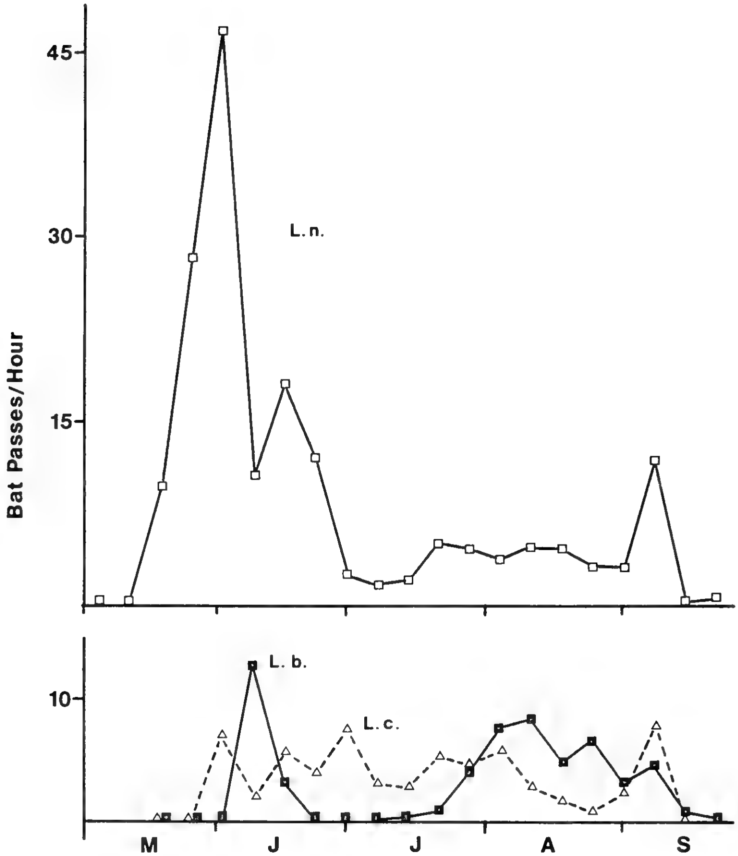

FIGURE 3. Seasonal activity of the three migratory bats at Delta Marsh, Manitoba during 1982 as measured by monitoring their echolocation calls. L.n. = *L. noctivagans,* L.b. = *L. borealis,* L.c. = *L. cinereus.*

be found in a territory since the bats were not individually marked.

Fourteen individuals and groups of Hoary Bats were located roosting in the ridge during 1982 and four in 1983. Groups consisted of an adult female and her two young. Although some of the groups in 1982 were likely the same, having simply moved from one roost to another, at least four groups were present at any one time. The bats roosted high in trees (8–12 m above the ground) on the south side of the ridge in areas providing an unobstructed flight path. Eight of ten trees used as roosts were Green Ash (*Fraxinus pennsylvanicus*), in which the bats roosted out near the end of a branch, occasionally in the midst of a clump of seeds. One family group was observed in the same location for 41 days while another apparently moved between two trees 10 m apart when the young first became volant, and were observed together for a total of 34 days. The young in these two groups took their first flights on 31 and 12 July respectively but each group remained together for over two weeks after that. During this time, the female left the roost to forage each night while it was still quite light (between 30 and 60 min after sunset) and the young left up to 30 min later and appeared to forage independently of her and each other.

Discussion

Of the six species of bats known to occur in Manitoba (Banfield 1974), at least four occur regularly at

Delta Marsh. Tamsitt (1962) found Little Brown and Silver Haired Bats in the area and considered them to be the only species present. Hoary Bats, however, have been found roosting in the dune-ridge before (Sealy 1978). Red Bats were thought to be fairly uncommon in the province (R. E. Wrigley, personal communication) and have not been reported from Delta before. However, it is the most common species at certain times of the year although it is rare during mid-summer and females do not regularly give birth there. It seems likely that Red, Hoary and Silver Haired Bats, which are all presumed to be migratory (Kunz 1982; Shump and Shump 1982; Findley and Jones 1964), follow the shoreline of Lake Manitoba during migration, much as migrating birds moving through Delta do. The least abundant species, the Little Brown Bat, and the two Manitoban species not occurring at Delta, are hibernators as opposed to migrators. Their scarcity is likely due to the lack of suitable hibernacula in southern Manitoba.

All species were less abundant in 1983 than 1982, perhaps as a result of abnormally cold spring temperatures in 1983. Normal May minimum temperatures at the Field Station average 4.8° C, whereas the average minimum for May 1983 was 1.7°C and frosts were recorded on 20 and 25 May. The cold temperatures and associated lower insect abundances may have slowed northward migration of the bats, particularly females which migrate north while pregnant and must halt their movements as they near parturition.

The temporal segregation of the sexes of Red Bats during their southward migration has been noted elsewhere (Kunz 1971) although no satisfactory explanation for it exists. Why individuals do not remain at Delta all summer is also curious since the high densities of insects produced from the lake and marsh should provide an abundant food source, and the ridge should provide suitable roost sites.

Hoary Bats appear to be regular summer residents in the forested ridge (Sealy 1978; this study). Although I could not pinpoint most parturition dates for the groups I observed, they fall within the dates found in other areas of the species' range (Barbour and Davis 1969). The fact that family groups remain together for a relatively long time after the young are volant may be due to the fact that, unlike hibernating species, females need not build up their own fat reserves in preparation for the winter and can thus afford to prolong parental care.

All species began to feed early in the evening compared to other areas of their ranges (e.g. Barbour and Davis 1969), likely in response to the short nights at this northern location. They forage primarily along the lee side of the ridge, the area preliminary data (unpublished) indicates has the highest insect densities. The territories defended by Hoary Bats likely contain even higher densities of insects due to the sheltering effect of the ridge and attraction of insects to lights. Hoary Bats have been observed feeding at lights in other areas (Fenton et al. 1983) and such locations are probably a valuable resource. Since Hoary Bats are the largest bats in my study area they may be physically capable of defending that resource from other species. Similar territorial behaviour has been noted in the Hawaiian subspecies of *L. cinereus* (Belwood 1982).

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A Comparison of Seed Reserves in Arctic, Subarctic, and Alpine Soils

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Archibold, O. W. 1984. A comparison of seed reserves in arctic, subarctic, and alpine soils. Canadian Field-Naturalist 98(3): 337–344.

Soil cores to a depth of 10 cm taken from various arctic, subarctic, and alpine sites were tested for the presence of buried viable propagules by stimulating emergence in the laboratory. An average rate of emergence of 741 individuals/m² was recorded for the three arctic sites, of which 84% came from seed; the majority were shrubs and herbs with the greatest density occurring in the dry tundra soil. Non-germinating seeds were extracted at an average density of 223/m². Emergence was lowest for the subarctic soils, averaging only 435 individuals/m², all of which were grasses and sedges which developed vegetatively. However, a large complement of non-germinating seed was also found, averaging 229 seeds/m². Plant diversity and density were highest for the Alpine sites, with an average rate of emergence of 8419 individuals/m², nearly all of which (95%) developed vegetatively. Sedges were best represented here, although herbs were also common. Non-germinating seeds averaged 432/m². Reserves of buried seed are comparatively low in these tundra environments; hence, vegetative processes are important to the maintenance and colonization of tundra sites.

Key Words: buried seeds; vegetative reproduction; Churchill, Manitoba; Rankin Inlet, Northwest Territories; Plateau Mountain, Alberta; soil cores.

The adaptation of arctic and alpine plants to their harsh environment has been widely documented (see for example Billings 1974; Billings and Mooney 1968; Bliss 1962, 1971; Porsild 1951; Savile 1972). Most species are perennial, and vegetative reproduction, making use of food reserves stored in underground tissues, is important in propagating the plant cover, especially in the more severe regions. However, seed production is common and many studies have been conducted on the seeding habits of tundra plants (see for example Amen 1966; Bell 1975; Bell and Bliss 1980; Bliss 1958; Pelton 1957; Sayers and Ward 1966; Sorensen 1941; Steshenko 1963, 1966), focusing particularly on seed dormancy and the germination requirements of selected species in both laboratory and field tests. Most tundra species produce non-dormant seeds, although Amen (1966) suggested that stratification may promote germination in some species. Germination appears to be largely controlled by air temperature and moisture availability with temperatures between 18°C and 22°C being optimal for many alpine species (Amen 1966) while temperatures as high as 30°C may be promotive for arctic species (Billings and Mooney 1968). Seedling establishment is uncertain (Bell 1975; Wager 1938): low temperatures, drought, and frost activity in the soil may lead to the demise of the young plants.

Because of their perennial habit, abundant seedling establishment is not essential for the maintenance of most species. Hence, large reserves of viable seed in tundra soils would not be required. Further, the potential for seed accumulation is low. Poor seed yields in unfavourable years, lack of seed dormancy, and perhaps rodent predation would all limit seed storage. The decline in the number of buried viable seeds poleward is discussed by Johnson (1975). He attributes the decrease to the general depauperization of the herbaceous flora in higher latitudes and to the shorter growing seasons which dictate rapid germination if seedlings are to be successful. Thus, Elliott (1979) reported on the paucity of seed reserves in the soils of the forest-tundra ecotone of Keewatin, Northwest Territories, and Whipple (1978) similarly noted a low seed density in subalpine forest soils in Colorado. However, McGraw (1980), working in a Cottongrass tussock tundra in Alaska, calculated seed reserves at 3367.3/m² and large seed banks have been reported by Lachenbruch (1981) and Gartner et al. (1983), again from arctic tussock tundra. The majority of these seeds were stored in the organic soil layers. McGraw (1980) indicated that 59% of the viable seed came from the top 5 cm, 25% from depths of 5–10 cm, 12% from depths of 10–15 cm with 4% found below 15 cm. Gartner et al. (1983) reported buried seed to depths of 30 cm.

In the present study soil cores taken from various arctic, subarctic, and alpine sites have been tested for buried viable propagules and the relative importance of seed reserves and underground vegetative organs has been assessed.

Study Areas

The arctic materials were collected from the vicinity of Rankin Inlet, Northwest Territories (62°48′N,

92° 15′W). Three different microsites were selected within the low-lying glaciated topography. Site one comprised a dry Lichen-heath *(Alectoria nigricans —Cassiope tetragona)* community located on a stony upland area. Site two was a wet, sedge-grass community developed on low-lying stony till. The third site, dominated by sedges, was associated with gently sloping, moist, tussocky terrain. The sample area for the subarctic region was Churchill, Manitoba (58° 45′N, 94° 12′W). Again three distinct sites were selected. The first was a wet sedge-grass community with Cottongrass *(Eriophorum angustifolium)* prominent; the second was a dry ericaceous heath associated with Arctic Avens *(Dryas integrifolia)* and various sedges and grasses. Thirdly, a treeline stand of 200-year old White Spruce *(Picea glauca)* was sampled. Four sites were chosen in the alpine area. One was a treeline site at about 2300 m elevation on Fortress Mountain, Alberta (50° 49′N, 115° 13′W), located in a 50-year old postfire stand of Alpine Fir *(Abies lasiocarpa)*. The other sites were on Plateau Mountain, Alberta (50° 13′N, 114° 32′W): a treeline stand of Alpine Fir at approximately 2400 m elevation, a seepage fen dominated by grasses and sedges, and a dry alpine meadow with occasional low growing, shrubby birches were selected.

Methods

Field work was carried out in late August 1979 at the Rankin Inlet and Churchill locations, and in early October 1979 in the mountain sites. The plants were considered to have reached a similar phenological stage at all locations, the majority having shed their seed at the time of sampling. Three parallel transects, 5 m apart, were established at each sample site with 12 sample points, also 5 m apart on each transect. Two cylindrical core samples (6 cm diameter, surface to 10 cm deep) of litter and soil were taken at each sample point. The paired samples were combined, bagged, and stored in the dark at − 10°C till February 1980. The soil was then spread out in 15 × 20 × 4 cm plastic germination trays. Germination was carried out at room temperature, which fluctuated between 20.0 and 25.0°C with tap water applied as required to keep the samples moist. Illumination (approximately 7500 lux) was provided by fluorescent lights set initially to an 18 h photoperiod. This was increased to 20 h at the end of the three weeks and reduced after three months by 1 h per week to 16 h, to simplify plant identification by simulating the shortening growing season, promoting flowering. Eight trays containing only sterilized soil were also set out to detect any contamination; no emergents developed in these control trays. Emergents were counted each week over a four-month period with identified individuals being removed to reduce competition. Where several stems arose vegetatively from a single root stock, each was counted. For grasses, each culm was counted individually. Finally, the samples were screened for non-germinating seeds using the technique of Malone (1967); however, these were not tested for viability. Although several taxonomists were consulted, the premature death of some emergents and the immature state of others, caused difficulties with plant identification. Some species therefore have been assigned a letter code, and even where identification is given this should be regarded as tentative. Nomenclature follows Hultén (1968) and Porsild (1974).

Results

The number of emergents arising from the arctic and subarctic soil cores is given in Table 1. The greatest diversity and the highest density of emergents occurred in the dry tundra soils from Rankin Inlet, with 1917 individuals/m^2 developing comprised of eight species. Unfortunately, five of these species (A-E) could not be identified but are shown in Figure 1. These species, together with Arctic Heather *(Cassiope tetragona)* and Crowberry *(Empetrum nigrum)*, accounted for 97% of the emergents from this site, the remaining 3% was comprised of sedges (*Carex* sp.). In addition, non-germinating seeds were extracted from the soil at a density of 393/m^2: the majority of these was derived from Crowberry. Total emergence from the hummocky tundra soils was 157 individuals/m^2 and was dominated by shrubs and herbs, with sprouts of Arctic Heather the most abundant, accounting for 38% of the emergents. Sedges were less important accounting for 13% of the total emergents, although non-germinating achenes from sedges (possibly *Carex maritima*) were common (118 achenes/m^2) in the cores and accounted for 43% of the total propagule count at this site. The developing plants (148 individuals/m^2) and non-germinating seeds (157/m^2) found in the wet tundra site at Rankin Inlet were dominated by sedges (possibly *Carex bigelowii*) which accounted for 97% of the total propagule count.

At Churchill, the largest number of propagules (1396/m^2) was recorded at the wet boggy site with Cottongrass and sedges accounting for 89% of the total. Non-germinating seeds were comprised of sedge achenes (452/m^2), together with seeds from Crowberry (128/m^2) and Bog Rosemary (*Andromeda polifolia* 20/m^2). Sedges were also abundant at the dry heath site, with 472 individuals/m^2 arising from the soil and a further 39 achenes/m^2 extracted by sieving. Together this accounted for 98% of the total propagule count for the site, the remainder being made up of sprouts of *Poa*

TABLE 1. Number of emergents arising from soil cores taken from arctic and subarctic sites (individuals/m²).

	Rankin Inlet Dry Tundra	Rankin Inlet Wet Tundra	Rankin Inlet Hummocky Tundra	Churchill Wet Bog	Churchill Dry Heath	Churchill Treeline
Herbs and Shrubs						
*Cassiope tetragona**	79		59			
*Empetrum nigrum**	20					
Species A	59	10				
Species B	1159		49			
Species C	452		29			
Species D	79					
Species E	20					
Total	1868	10	137			
Grasses and Sedges						
Carex sp.*	49	138	20	118	472	29
Eriophorum sp.*				678		
Poa sp.*					10	
Total	49	138	20	796	482	29
Non-germinating Seeds						
Andromeda polifolia				20		
Carex sp.	10	157	118	452	39	39
Eleocharis sp.						10
Empetrum nigrum	383			128		
Total	393	157	118	600	39	49
TOTAL	2310	305	275	1396	521	78

*Developed vegetatively.

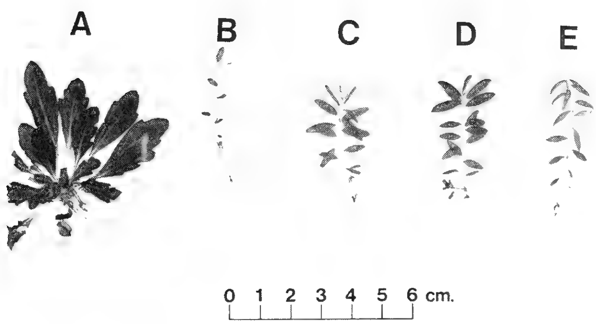

FIGURE 1. Unidentified seedlings which developed from various soil cores taken from Rankin Inlet.

sp. Soils beneath the spruce stand contained the smallest reserves of propagules, totalling 78/m², all of which came from sedges.

Plant diversity and density were comparatively high for the soils taken from the alpine sites on Plateau Mountain (Table 2) with 16 genera recorded for the seepage fen and 17 genera identified at both the treeline site and the dry meadow. These, together with unidentified individuals and non-germinating seeds, gave total propagule counts ranging from 1759/m² at treeline, to 10855/m² in the fen, to 21859/m² in the meadow. However, on Fortress Mountain, emergence totalled only 931/m² and comprised five genera. At this site herbs accounted for 42% of the total, although the most common species (L, Figure 2) could not be identified. The remainder was made up of various grasses and sedges (28%), the Fern *Cystopteris fragilis* (19%), and Cranberry (*Vaccinium vitis-idaea* 11%). At the treeline site on Plateau Mountain, herbs were most abundant, accounting for 61% of the total emergents, with Alpine Speedwell *(Veronica alpina)* best represented at 393 individuals/m² and *Androsace septentrionalis* also important (196 individuals/m²). Grasses and sedges represented 25% of the total emergents with shrubs and trees at 9% and ferns at 5%. The Alpine Fir recorded at this site developed vegetatively. The greatest density of herbs emerged from soil taken from the seepage fen (6856/m²); these accounted for 63% of the emergents at this site with Harebell (*Campanula rotundifolia* 3036 individuals/m²) and Chickweed (*Stellaria longipes* 1935 individuals/m²) being very important. Grasses and sedges were also common, with a total of 3695 culms/m² emerging. However, the greatest density of grasses and sedges was found in the dry meadow site from which 16867 culms/m² arose, accounting for 77% of the total emergents. Herbs were also important here, with 3499 individuals/m² arising dominated by *Stellaria longipes* at 1415 individuals/m². Differences in emergence rates within sites are given in Table 3. As with all studies of buried propagules, intrasite variation is high. Table 4 provides a summary of the emergence data for each location.

Discussion

From the species lists given in Tables 1 and 2 it can be seen that the majority of the plants developed vegetatively. Of the total number of plants which emerged from the soil cores, approximately 10% developed from seed. However, as shown in Table 4, these seedlings were not uniformly distributed throughout the three sampling regions. On a regional basis, the highest proportion of seedling emergence occurred in the arctic sites where 84% of the plants developed from seed. The majority was associated with the dry tundra soils. In the alpine sites 4% of the plants developed from seed, the greatest proportion being found in the treeline site on Fortress Mountain, although in absolute terms the largest seed reserves occurred in the dry meadow soils from Plateau Mountain. No seedlings emerged from the subarctic soils. Such a high percentage of seedlings in the arctic sites is surprising since the general consensus is that sexual reproduction and seed production is limited in more severe environments (Bell and Bliss 1980; Savile 1972), with conditions during the short growing season significantly affecting the amount of seed produced.

However, some of the variability recorded in this study could reflect the conditions under which the germination trials were conducted; it is unlikely that light levels, moisture conditions, or temperatures in the laboratory would be suitable for all species. Leck (1980), working at Barrow, Alaska, reported seed banks of 204.8/m² for *Chrysosplenium tetrandum* based on growth chamber studies, although only 39.2/m² were found in similar soils under greenhouse conditions. Likewise, conditions during the period of cold storage, such as soil moisture levels, may have affected seed viability and dormancy. In addition, seed release may have occurred at different times relative to the period of sampling, although this appeared to have been completed at all sites: the precise timing of field sampling is essential for comparing seed reserves. Wein and MacLean (1973) reported high germination rates for Cotton Grass seeds collected within two weeks of initial seed dispersion, but noted a significant decline in viability for seed shed later in the season and a further decline in viability with storage.

Compared to those from more temperate environments, the buried seed reserves in the tundra soils are very low, and those seedlings which did develop were very delicate. Bonde (1968) reported on the improved growth of seedlings of *Trifolium nanum* which had been transplanted to greenhouse conditions. It is therefore unlikely that many of the seedlings recorded in this study would have survived in the field under conditions of moisture stress, temperature fluctuations, competition, and herbivory. The absence of tree seeds in the soils agrees with the studies of Elliott (1979); she found an absence of buried viable seed from northern tree species in the forest-tundra ecotone and concluded that the forest cover is maintained by layering. She suggested, like Nichols (1976), that seed production is restricted to periods of climatic amelioration, although Wein (1974) recorded the establishment of Black Spruce *(Picea mariana)* in a forested area near Inuvik. Tree seeds were absent from the two subalpine sites studied by Whipple (1978) although they did yield the equivalent of 3.2 seeds/m² and 52.8/m² respectively. These values are much lower than those recorded in this study (Table 4). McGraw's (1980) estimate of 3367.3 seeds/m² in

TABLE 2. Number of emergents arising from soil cores taken from alpine sites (individuals/m^2).

	Fortress Mountain Tree Line	Plateau Mountain Tree Line	Plateau Mountain Seepage Fen	Plateau Mountain Dry Meadow
Herbs				
*Allium schoenoprasum**				10
Androsace septentrionalis (J)		196	157	
*Antennaria lanata**				49
*Arenaria capillaris**				118
*Astragalus alpinus**		49		
*Campanula rotundifolia**		79		
*Cerastium beeringianum**			3036	472
Draba sp. (I)*		20	265	39
Epilobium alpinum			20	59
Epilobium angustifolium	128			
*Oxyria digyna**			609	
*Parnassia fimbriata**			128	
*Pedicularis contorta**			29	
*Penstemon procerus**		108		49
*Polemonium pulcherissimum**		10		
Polygonum viviparum (K)*				236
*Potentilla diversifolia**		49	157	531
*Potentilla fruticosa**			118	10
Saxifraga sp.*		29	88	
*Sedum lanceolatum**		20		98
*Senecio pauciflorus**			29	
*Stellaria longipes**			1935	1415
Taraxacum sp. (F)		20	157	49
Veronica alpina		393		49
Species G			49	
Species H				138
Species L	265	98	79	226
Total	393	1071	6856	3499
Shrubs and Trees				
*Abies lasiocarpa**		88		
*Phyllodoce glandulifera**		49		
Salix sp.*		19		
*Vaccinium vitis-idaea**	98			
Total	98	156		
Grasses and Sedges				
*Carex sp.**	88	196	884	6975
Poa sp.*		20	2289	9735
Unidentified*	176	217	522	162
Total	264	433	3695	16867
Ferns				
*Cystopteris fragilis**	176	99	10	59
Non-germinating Seeds				
Carex sp.			39	246
Cerastium sp.			59	
Chenopodium sp.				29
Potentilla sp.			176	1159
Stellaria sp.			20	
Total			294	1434
TOTAL	931	1759	10855	21859

*Developed vegetatively.

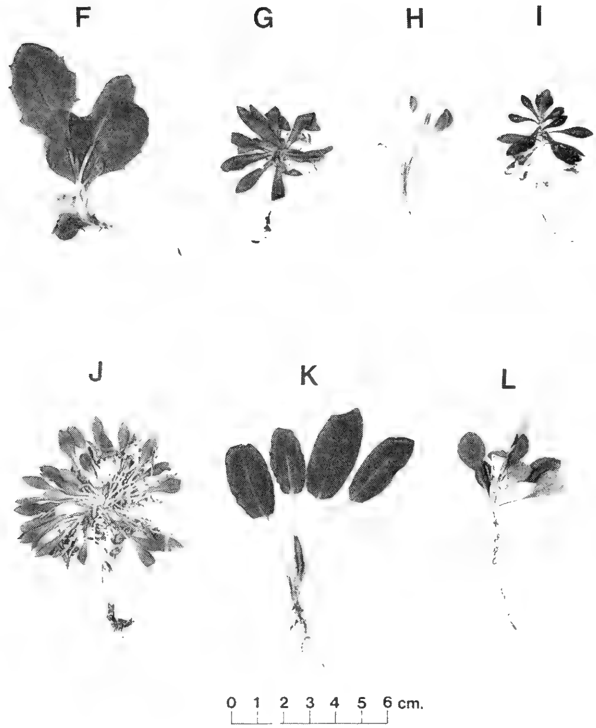

FIGURE 2. Various seedlings which developed from the alpine soil cores. G, H, and L could not be identified; tentative identification of the other plants is given in Table 2.

organic terrain in central Alaska is considerably higher than data from comparable sites at Rankin Inlet. Here, seedling emergence rates of $10/m^2$ and $78/m^2$ were recorded for wet and hummocky tundra respectively, with 157 and 118 non-germination seeds/m^2 also found. At Churchill, no seedlings emerged, although non-germinating seeds were estimated at $600/m^2$ in the wet bog.

Because of the presence of permafrost, the tundra region is particularly sensitive to disturbance and several studies have investigated the impact of increased resource exploration activity on the vegetation. Hernandez (1973) concluded that vegetative spread was the principal method of plant development on disturbed sites. Seedling establishment was not abundant, although Younkin (1973) noted that under laboratory conditions seed of all of the species commonly found in disturbed areas had relatively high rates of germination. Where disturbance has been severe, recolonization is slow and studies by Dabbs et al. (1974) on the progress of natural recolonization of backfilled sites showed that after two years the cover of vascular plants remained sparse. The majority of the seed reserves are found in the surface organic soil layers (Gartner et al. 1983; Lachenbruch 1981; McGraw 1980). Hence, careful removal, storage and replacement of this organic material during construction programmes may accelerate recolonization, although a rapid loss in viability could be expected. Without a source of viable seed, natural revegetation can only occur through gradual vegetative spread: the results of the present study suggest that this must ultimately be the dominant process in tundra environments.

TABLE 3. Mean and standard deviations of numbers of emergents and non-germinating seeds per square meter in arctic, subarctic, and alpine sites. Coefficients of variation (percentage) given in parentheses. Sampling replication was N = 36.

	Trees, Shrubs and Herbs	Grasses and Sedges	Ferns	Non-germinating Seeds
Rankin Inlet				
Dry Tundra	51.8 ± 37.1 (72)	1.4 ± 3.4 (243)		10.9 ± 18.8 (172)
Wet Tundra	0.3 ± 1.6 (533)	3.8 ± 8.8 (238)		4.4 ± 9.5 (216)
Hummocky Tundra	3.8 ± 5.4 (142)	0.6 ± 2.3 (383)		3.3 ± 5.7 (173)
Churchill				
Wet Bog		22.1 ± 35.8 (162)		16.7 ± 29.9 (179)
Dry Heath		13.4 ± 13.6 (101)		1.1 ± 3.1 (282)
Treeline		0.8 ± 2.8 (350)		1.4 ± 3.4 (243)
Fortress Mountain				
Treeline	13.6 ± 15.2 (112)	7.4 ± 9.2 (124)	4.9 ± 10.1 (206)	
Plateau Mountain				
Treeline	34.1 ± 50.9 (149)	12.0 ± 17.5 (146)	2.7 ± 8.3 (307)	
Seepage Fen	190.4 ± 122.7 (64)	102.6 ± 160.5 (156)	0.3 ± 1.6 (533)	8.2 ± 15.3 (187)
Dry Meadow	97.1 ± 43.2 (44)	468.6 ± 254.4 (54)	1.6 ± 4.9 (306)	39.8 ± 46.8 (118)

TABLE 4. Density (per m^2) of emergents which developed vegetatively and from seed, and non-germinating seeds. Intrasite percentages given in parentheses.

Site	Emergents Developed Vegetatively	Emergents from Seed	Non-germinating Seed
Rankin Inlet			
Dry tundra	148 (6)	1769 (77)	393 (17)
Wet tundra	138 (45)	10 (3)	157 (52)
Hummocky tundra	79 (29)	78 (28)	118 (43)
Churchill			
Wet bog	796 (57)		600 (43)
Dry heath	482 (93)		39 (7)
Treeline	29 (37)		49 (63)
Fortress Mountain			
Treeline	538 (58)	393 (42)	
Plateau Mountain			
Treeline	1248 (71)	511 (29)	
Seepage fen	10256 (94)	305 (3)	294 (3)
Dry meadow	19904 (91)	521 (2)	1434 (7)

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The Biological Flora of Canada.
5. *Delphinium glaucum* Watson, Tall Larkspur

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Looman, J. 1984. The Biological Flora of Canada. 5. *Delphinium glaucum* Watson, Tall Larkspur. Canadian Field-Naturalist 98(3): 345–361.

Delphinium glaucum Watson, Tall Larkspur, is found in the forested range and grasslands of the Rocky Mountains, and in the western boreal forests. It is a species characteristic for conditions prevailing in transitional vegetation. Although usually occurring with low densities, it can occasionally be very abundant. It grows primarily on soils low on phosphorus and nitrogen. Because Tall Larkspur is extremely poisonous, its occurrence on cattle range can lead to considerable livestock losses, and also affect wildlife such as Elk and perhaps Bison.

Key Words: *Delphinium glaucum*, Tall Larkspur, Pied d'alouette, biology, ecology, phenology, distribution, economic importance.

1. *Name*

Delphinium glaucum Watson (Watson 1880, p. 427). Type: W. H. Brewer, 1940, Big Tree Road, 6000 ft., Mariposa Co., Calif., 1863 (GH) Ranunculaceae.
D. scopulorum Gray var. *glaucum* (Watson) Gray, (Gray, 1887, p. 52).
D. scopulorum Auctorum, not Gray.
D. brownii Rydb. (Ryberg 1902, p. 148). Type: A. Brown, 13 VIII 1893, near Banff, Alberta (NY).
D. canmorense Rydb. (Ryberg 1917). Type: J. Macoun 1 VII 1885, near Canmore, Alberta (NY).
Tall Larkspur; Pied d'alouette.

2. *Description of the Mature Plant*

(a) *Raunkiaer life form: D. glaucum* belongs to the *geophyta* in Raunkiaer's classification of life forms. In this class, buds overwinter below the surface of the soil. *D. glaucum* may be grouped in the *geophyta radicigemmata*, which include plants budding from the roots (Raunkiaer 1905; Braun-Blanquet 1951). Buds form in late fall, usually after the above-ground parts have been killed by frost. Plants are long-lived; transplanted specimens have survived for more than 20 years.

(b) *Shoot morphology:* Stems 1–6, simple, usually erect, 75–200, or occasionally 300 cm tall, up to 156 mm thick, hollow; glabrous, or with a few lines of hairs when young; more or less densely pubescent or glandular pubescent above; often purplish tinged in the lower parts. Leaves many, cauline, the lower ones on petioles 6–15 cm long, the petiole length decreasing to 1–2 cm below the inflorescence (Figure 1). Leaves variable, the blade semi-circular to almost circular in outline, 10–15 cm across, divided into 3–5 primary segments, these deeply incised at the apex into lanceolate or linear-lanceolate, acute to acuminate or somewhat rounded lobes; petioles more or less densely pubescent; blades sparsely pubescent to sub-glabrous above, sparsely to densely pubescent below.

(c) *Root morphology:* Roots in young plants often tuberous, later becoming stout and woody, to 15 cm long, 2–3 cm thick, forming a caudex with 3 or 4 branches at the summit. Fibrous root system well developed, reaching 60–70 cm depth; 75–85% of the root system is in the top 15 cm of the soil.

(d) *Inflorescence:* The inflorescence is a rather narrow spicate raceme, 10–35 cm long; the branches if present appressed-ascending. Pubescence of basifixed, white or somewhat yellowish, flat hairs, 0.2–0.5 cm long; flowers more or less numerous, seldom less than 20, often 60 or more; the upper ones single on short pedicels, the lower ones often on branches with 2–5 flowers, but racemes often unbranched; upper bracts small or absent, lower bracts 10–15 mm long, lanceolate or divided into 3 narrowly linear-lanceolate segments. Flowers irregular, 15–20 mm long, with 5 petal-like sepals, 9–12 mm long, 3–5 mm wide, delicately yellowish-veined, pubescent, the upper sepal prolonged into a spur, 8–11 mm long, tapering to 1 mm wide at the upturned tip, pubescent, the upper pair prolonged into spurs, 4–6 mm long, included in the spur of the calyx; the spurs contain the nectar; petals 10–12 mm long, the lower ones ciliolate, the sinus about 1 mm deep, bearded, the upper ones white- or

FIGURE 1. *Delphinium glaucum* Watson. Looman *20341*: Burnt Timber Creek, Alberta, about 1500 m.

yellowish-edged, included, glabrous (Figure 2). Stamens about 30, the filaments 4–5 mm long, widened to 1 mm at the base; anthers 1 mm long, purplish-black, two-celled. Pollen hyaline, triporate, spheroid, 40–50 microns in diameter. Follicles 3, erect (Figure 3), oblong, cuspidate, 11–14 mm long, glabrous and reticulate-veined, or sometimes more or less densely pubescent, the valves membranous; at maturity dehiscing to the base, spreading. Seeds black, elliptic, 2–3 × 1 mm, oval in cross-section, narrowly to broadly winged.

(e) *Subspecies:* None described.

(f) *Varieties and forms:* Plants with white or nearly white flowers have been distinguished as forma *pallidiflora* Boivin. A form with densely pubescent follicles and glandular pubescent in the inflorescence was described by Rydberg as *D. canmorense,* but this name is considered a synonym (Scoggan 1978).

(g) *Ecotypes:* No evidence of ecotypic variation has been observed. Although plants growing at high altitudes are smaller than those at lower altitudes, offspring grown from seed at High River, Alberta, and Swift Current, Saskatchewan, did not differ from plants growing at lower altitudes.

(h) *Chromosome numbers:* Ewan (1945) mentions $2n = 16$. My counts on four specimens from the Rocky Mountains also showed $2n = 16$. (Burnt Timber Creek, Looman *20341,* 1974, 1500 m; Red Deer River crossing, Looman *20336,* 1974, 1500 m; Eureka River, Looman *18215,* 1973, 690 m; McLeod River, Looman *22605,* 1978, 1675 m). Coordinates for these locations are given in Appendix 1.

3. *Distribution and Abundance*

(a) *Geographic range: D. glaucum* occurs in the boreal forest zones of western Canada, as well as subarctic regions within the tree-zone, and in the Rocky Mountains below the treeline. Its distribution is restricted to western regions (Figure 4). The species occurs in the Rocky Mountains, North West Territories, Yukon Territory (Raup 1947, map), the boreal forest regions and interior mountain ranges of British Columbia, Alberta, and sporadically in western Saskatchewan (Moss 1959; Looman and Best 1979). Boivin (1969) gives the distribution as "Native . . . from about the center of Saskatchewan westward" but in west-central Saskatchewan and adjoining parts of eastern Alberta the species is very rare. Scoggan (1978) gives the range in Saskatchewan as "(N to Meadow Lake, 54°08N)", which gives the false impression that the species is "southern". In the United States it occurs from Washington and Oregon in the west to the Rocky Mountains in the east, south to Wyoming and Nevada and northern California and in Alaska (Hultén 1968, map).

(b) *Altitudinal range:* The species has a wide altitudinal distribution. It has been collected or observed at altitudes up to 2450 m near Mt. Edith Cavell, Alberta while in the boreal forest and arctic zones it occurs at altitudes below 100 m. In more southern parts of its range the species has been collected at altitudes above 3000 m; Ewan (1945) cites a collection in northern California at 3230 m.

4. *Physical Habitat*

(a) *Climatic relations: D. glaucum* occurs at a wide range of climatic conditions. However, dividing the area of its distribution into regions according to geographic location and altitude, and averaging climatic data (Environment Canada 1973a, b) for these regions, climatic diagrams can be constructed (Walter 1963, Looman 1977). These diagrams (Figure 5), depicting the climate graphically, allow for an easy comparison of the most outstanding features. Thus, comparing the diagrams for the regions in which *D. glaucum* occurs, it is evident that only the Yukon-NWT experience a brief and mild dry period. During the major part of the growing season, however, this region also has ample precipitation. Besides the climatic factors incorporated in the diagrams it is noteworthy that daylength increases from south to north by about 2.5 hrs, in effect reducing the difference in length of the growing season.

(b) *Physiographic relations:* The species occurs in the margins of forests, open woods, moist draws, willow thickets, and grassland-forest transitions, with generally mesic moisture conditions. Soils on which *D. glaucum* occurs are much like those supporting *D. bicolor* Nutt. (Looman 1975). In the margins of coniferous forests where the species occurs the L-H layer may be up to 10 cm thick if grazing by domestic cattle is not excessive. In deciduous woods the L-H layer may reach 10–15 cm thickness, but the L layer may be virtually absent where grazing has eliminated most of the herbaceous ground cover. Also, the thickness of the layers increases with age of the trees. Grasslands in which *D. glaucum* occurs in some abundance may have L-H layers totalling 3–5 cm. Grazing by domestic cattle usually causes the species to disappear from the open grassland, but it may persist in semi-open parts where shrubs provide protection. Soils can be classified according to habitat and location. Several soil orders (Canada Department of Agriculture 1978) are represented. These include Chernozemic soils

FIGURE 2. *Delphinium glaucum* Watson. Inflorescence. Nigel Creek Valley, Banff National Park, Alberta, about 1980 m. Photo: Julie O. Hrapko.

FIGURE 3. *Delphinium glaucum* Watson, showing flowers and mature follicle: West of La Glace, Peace River district, Alberta, about 730 m. Photo: Julie O. Hrapko.

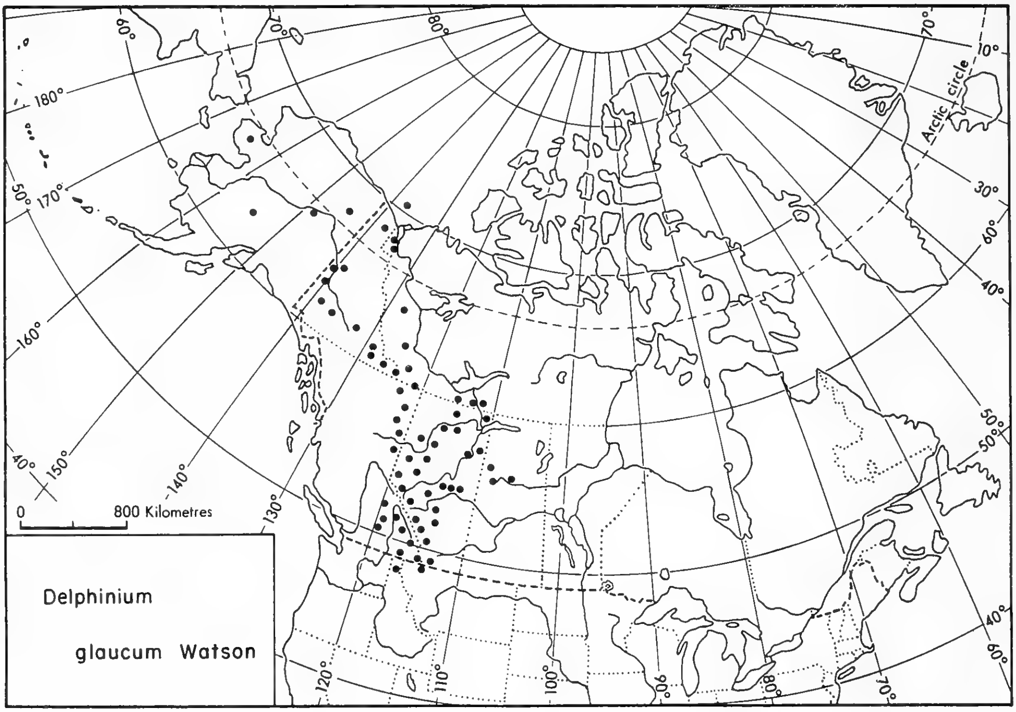

FIGURE 4. Canadian distribution of *Delphinium glaucum*. Loan of specimens from the following herbaria is gratefully acknowledged: University of Alberta, Edmonton; University of Calgary, Calgary; University of Saskatchewan, Saskatoon; Canada Agriculture, Ottawa.

in most of the foothills of the Rocky Mountains, particularly in the grasslands and grassland-forest transitions, as well as in the parklands of the northern plains; Brunisolic soils, at higher elevations in the Rockies, and in the boreal forests; Podzolic soils in the boreal forest; Regosolic soils in the Rocky Mountains, particularly on slopes and ridges, and Gleysolic soils, almost exclusively where the species occurs in willow thickets. Results of analyses of 50 soil samples, taken to a depth of 10 cm, are given in Table 1 (locations are given in Appendix 1). As is evident from the error of the means for the soils on which the species occurs, *D. glaucum* has a wide range of tolerance for soil conditions.

(c) *Nutrient and water relations:* Nutritional requirements of the species have not been determined, but as noted in 4b, its range of tolerance for soil fertility is very wide. Transplants from the Alberta Rocky Mountains and east-central Alberta to a garden at Swift Current, Saskatchewan, were adversely affected by applications of fertilizer at a rate equal to that applied to a lawn, i.e., about 150 kg N + 50 kg P per hectare. Plants receiving the fertilizer produced fewer flowers and fewer seeds per capsule than plants in unfertilized locations. Despite maintenance of mesic to wet-mesic conditons, growth of plants has been less vigorous at Swift Current than in the natural habitat. Plants show a tendency to abnormal bending and twisting of the stems, but usually flower rather profusely, especially late inthe season, i.e., in the second half of September and early October, until freeze-up. Plants failed to survive dry to dry-mesic conditions. Seedlings growing amongst shrubs and under protection of spruce trees — all watered regularly — do not show any abnormalities. This may indicate that a humid microclimate is required for optimum growth.

5. *Plant Communities*

Delphinium glaucum is fairly common in the Rocky Mountains in transitions from fescue prairie to forest, in particular, to aspen or aspen-willow woods. In these surroundings it can be regarded as a kensort for this

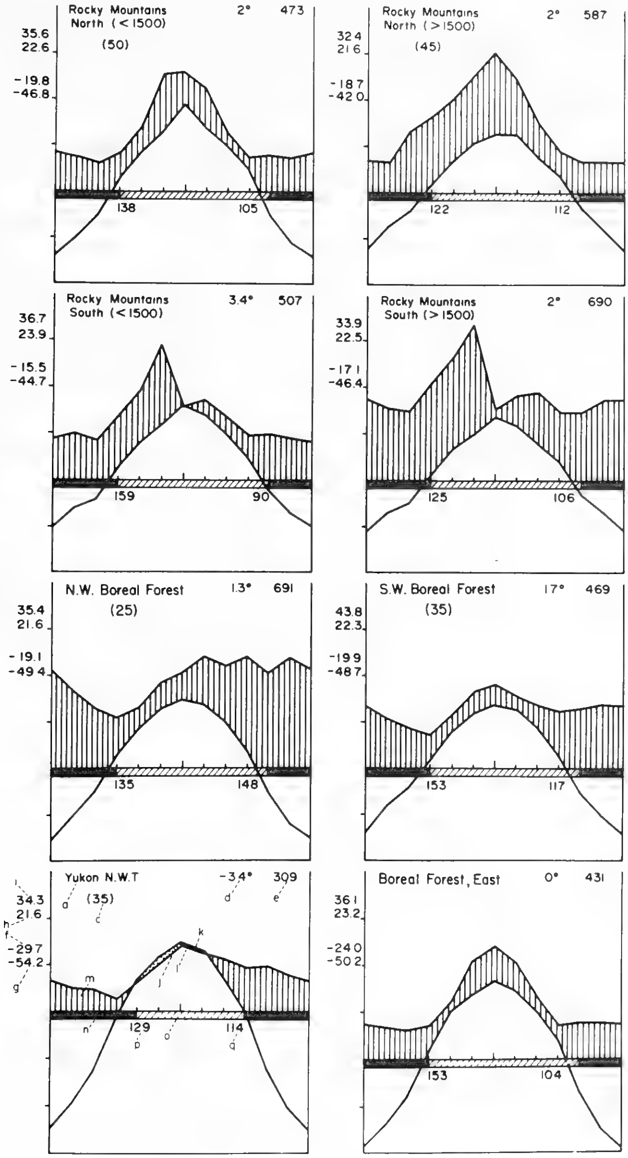

FIGURE 5. Climatic diagrams for the distribution areas of *Delphinium glaucum*.

a — area
c — number of recording stations
d — annual mean temperature, °C
e — annual precipitation, mm
f — mean minimum temperature
g — absolute minimum temperature
h — mean maximum temperature
i — absolute maximum temperature
j — mean monthly precipitation
k — mean monthly temperature
l — dry period
m — wet period
n — months with average temperature below 0° C
o — months with absolute minimum temperatures below 0° C
p — growing season in days
q — average number of days with measurable precipitation

TABLE 1. Characteristics of soil samples taken in 50 stands of five vegetation types containing *Delphinium glaucum*.

Vegetation types	pH	Conductivity	NO_3-N	NH_4-N	P	K	Ca	Mg
Southern Prairie	7.0 ± 0.1	490 ± 40	11.3 ± 1.1	13.6 ± 1.3	20.7 ± 2.5	242 ± 35	479 ± 31	43 ± 6
Northern Prairie	7.2 ± 0.2	370 ± 10	29.0 ± 6.0	24.5 ± 3.7	14.0 ± 1.0	117 ± 22	52 ± 15	19 ± 6
Aspen Groves	6.1 ± 0.3	360 ± 8	22.4 ± 6.7	26.2 ± 9.5	29.2 ± 5.8	75 ± 39	46 ± 16	15 ± 5
Open Pine Woods	5.2 ± 0.2	240 ± 6	1.5 ± 0.1	7.8 ± 1.0	19.9 ± 3.9	106 ± 20	31 ± 14	7 ± 2
Willow thickets	7.3 ± 0.2	1100 ± 8	13.9 ± 6.2	9.4 ± 3.2	12.6 ± 6.1	297 ± 71	102 ± 9	91 ± 11

Conductivity as μScm^{-1}; nutrients as mg/l.

TABLE 2. Occurrence of the most important species in communities with *Delphinium glaucum*.

Community type	Southern Prairie					Northern Prairie					Aspen Groves					Open Pine Woods					Willow Thickets				
Stand Number*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Area of Stand**	1	1	1	1	1	1	1	1	1	1	1	2	2	1	2	2	2	2	2	1	1	1	1	1	2
Shrub or tree cover, %	30	25	25	40	30	50	40	40	40	30	60	60	70	70	60	70	70	60	60	60	50	50	60	60	60
Total number of species	27	25	25	27	26	27	25	27	27	25	35	41	42	36	37	28	31	29	27	27	21	23	25	24	21
A. TREE LAYER:																									
Populus tremuloides Michx.	.	.	.	.	.	.	.	.	.	.	3	3	3	3	3	1	+	+	1	1	+	+	1	+	1
Populus balsamifera L.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	+	.	.	.	.	+	.	+	.	1	.
Pinus contorta Dougl. var. *latifolia* Eng.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	3	2	3	.	.	.	.	.	.	.
Pinus banksiana Lam.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	.	.	+	.	.
Picea glauca (Moench) Voss	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+	+	1	1	+	+	.	.	.	.	+
F. SHRUB LAYER:																									
Potentilla fruticosa L. ssp. *floribunda* (Pursh) Elk.	2	2	2	3	2	3	2	3	3	2	.	.	.	+	.	.	+	.	.	+	.	+	.	+	.
Salix bebbiana Sarg.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	2	1	2	2	1
Salix discolor Muhl.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	1	1	1	1
Salix glauca L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2	2	1	2	1
Salix lutea Nutt.	.	+	.	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.
Salix drummondiana Barr.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	+	.	.	+	.	1	.	1	+	+
Salix maccalliana Rowlee	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	1
Populus tremuloides Michx.	+	.	+	.	.	.	.	+	+	.	+	+	+	+	+	.	.	+	+	.	+	.	+	+	+
Betula glandulifera (Regel) Butler	.	.	.	.	.	+	.	+	.	+	.	.	.	.	.	.	+	.	.	+	.	+	1	+	+
Alnus incana (L.) Moench	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.
Cornus alba L.	.	.	.	.	.	.	.	.	.	.	1	1	+	.	1	.	.	+	.	.	.	+	.	+	+
Viburnum edule (Michx.) Raf.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	+	+	.	+	+	.	.	.	.	.
Shepherdia canadensis (L.) Nutt.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	+	+	.	+	+	.	.	.	.	.
Spiraea lucida Dougl.	.	.	+	.	.	.	.	.	+	.	.	.	.	+	+	.	+	.	+	+	.	.	.	.	.
Picea glauca (Moench) Voss	+	.	.	+	.	+	+	.	+	.	+	+	+	+	+	+	+	+	+	+	.	.	+	+	.
H. HERBACEOUS LAYER:																									
***Delphinium glaucum* Watson**	1	1	+	+	1	1	1	1	+	+	1	1	1	2	1	+	+	+	1	+	1	2	2	1	2
Festuca campestris Rydb.	2	2	1	1	+	.	.	.	.	.	+	.	+	+	.	.	+	.	.	.	.	.	.	.	.
Festuca idahoensis Elmer	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hedysarum alpinum L. var *americanum* Michx.	+	.	+	+	.	.	.	+	+	.	.	+	.	+	.	.	.	.	+	+	.	.	.	.	.
Danthonia intermedia Vasey	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Helictotrichon hookeri (Scribn.) Henr.	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dodecatheon conjugens Greene	+	.	+	+	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	+	.	.	+
Geranium richardsonii Fisch. & Trautv.	+	+	1	+	+	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.

(continued)

TABLE 2. *(Concluded).*

Community type	Southern Prairie					Northern Prairie					Aspen Groves					Open Pine Woods					Willow Thickets				
Stand Number*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Area of Stand**	1	1	1	1	1	1	1	1	1	1	1	2	2	1	2	2	2	2	2	1	1	1	1	1	2
Shrub or tree cover, %	30	25	25	40	30	50	40	40	40	30	60	60	70	70	60	70	70	60	60	60	50	50	60	60	60
Total number of species	27	25	25	27	26	27	25	27	27	25	35	41	42	36	37	28	31	29	27	27	21	23	25	24	21
Anemone multifida Poir.	+	.	+	+	.	.	.	.	.	.	.	+	+	+		+	.	+	.	.	+	.	+	.	.
Festuca altaica Trin.	.	.	.	.	.	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+
Deschampsia caespitosa (L.) Beauv.	.	.	.	.	.	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.
Trisetum canescens Buckl.	.	.	.	.	.	+	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Calamagrostis purpurascens R. Br.	.	.	.	.	.	+	+	+	+	+	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.
Stipa columbiana Macoun	.	.	.	+	.	+	+	+	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	+	.
Astragalus alpinus L.	.	.	+	.	.	+	.	+	+	+	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.
Antennaria umbrinella Rydb.	.	+	.	+	.	+	+	+	+	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.
Anemone parviflora Michx.	.	.	.	.	.	+	.	+	+	+	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+
Astragalus frigidus (L.) Gray var. *americanus* (Hook.) Wats.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+	+	.	.	+	+	.	.	.	.	.
Galium boreale L.	+	.	.	+	.	.	.	.	.	.	+	+	+	+	+	.	.	+	.	.	+	.	+	.	+
Smilacina stellata (L.) Desf.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	+	.	+	.	.	.	.	.	.	.	.
Schizachne purpurascens (Torr.) Swallen	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	+	.	.	+	+	.	.	.	.	.
Oryzopsis asperifolia Michx.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+	.	+	+	.	+	.	.	.	.	.
Actaea rubra (Ait.) Willd.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.
Agropyron trachycaulum (Line) Malte	.	+	.	+	.	.	.	+	+	.	+	+	+	+	+	+	.	+	+	.	+	.	+	.	+
Agropyron subsecundum (Link) Hitchc.	+	+	.	+	.	.	.	.	.	.	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.
Aster ciliolatus Lindl.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	+	.	+	+	.	+	+	.	+	.
Epilobium angustifolium L.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+	.	+	+	.	+	+	.	+	.	.
Lathyrus ochroleucus Hook.	.	.	+	.	.	+	.	.	.	.	+	+	+	+	+	.	.	+	+	.	.	.	.	.	.
Vicia americana Muhl. var. *americana*	.	.	.	+	.	.	+	.	.	+	+	+	+	+	+	+	.	+	+	.	+	+	.	+	.
Aster conspicuus Lindl.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	+	.	+	+	.	+	.	.	.	.	.
Elymus innovatus Beal	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+	+	+	+	.	.	.	.	.
Linnaea borealis L.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	+	+	+	+	.	.	.	.	.
Cornus canadensis L.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	+	+	+	+	+	.	.	.	.	.
Pyrola asarifolia Michx.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	+	+	+	+	.	.	.	.	.
Calamagrostis rubescens Buckl.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	.	.	.	.
Viola orbiculata Geyer	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	+	+	+	+	+
Galium triflorum Michx.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	+	+	.	.	.	.	.
Antennaria howellii Greene	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	.	+	.	.	.	.	.	.
Poa pratensis L. s.l.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+
Phleum pratense L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+
Taraxacum officinale Weber	.	.	+	.	.	.	.	.	.	.	.	+	.	.	+	.	.	+	.	.	+	+	+	+	+
Muhlenbergia glomeratta (Willd.) Trin. var. *cinnoides* (Link) Hermann	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+
Calamagrostis canadensis (Michx.) Beauv.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.
Hierochloe odorata (L.) Beauv.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+
Ranunculus macounii Britt.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.
Agoseris glauca (Pursh) Raf.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+

*Stands represent two or more stands in a given area; locations of areas are given in Appendix 1.
**Area of stands × 225 m^2.

transition, that is, a species characteristic for the conditions prevailing in transitional vegetation, as in the association Festucetum idahoensis subassociation elymetosum virginici Loom. 1969 (Looman 1969). In the northern forests, where the Festucetum does not occur, the species is found in willow thickets and open forests, as well as in clearings. Occasionally, it can be found in abundance in recently cleared land that has been allowed to revegetate. The species is all but absent from closed spruce forest. In Table 2 its occurrence in five major vegetation types is listed, with its abundance indicated on the abundance scale of Braun-Blanquet (1951), with "+" indicating presence as isolated plants, and "5" occurrence in great abundance with cover of 80–100%. The stands listed are representative for the vegetation types indicated; the total number of stands examined exceeds 130, in 50 of which soil samples were taken (Appendix 1). Although most of the stands were not grazed by domestic cattle, the Willow Thickets all were part of pastures, and some of the Aspen Groves were grazed. In addition to the areas listed in the Appendix, stands were examined in the Swan Hills and east central parts of Alberta, but coordinates for the locations are not available.

6. *Growth and Development*

(a) *Morphology:* Seeds germinate in spring, and seedlings develop two to four small leaves in the first year. These leaves are usually shallowly to deeply lobed, but in the second year five to seven dissected leaves are produced (Figure 6). In the first and second year growth is principally in the root system which becomes large compared to the size of the plants, and often somewhat tuberous. The root/shoot ratio of 10 seedlings was about 2.4:1 when determined in late September. In the third year leaves reach mature size and shape, and may be numerous. The root system also enlarges greatly, and may form two or more crowns. Observations on young plants in the garden at Swift Current showed that plants occasionally produce the first flowering stems in the fourth year, somewhat more frequently in the fifth year, but most commonly not until the sixth year.

(b) *Physiology:* No physiological studies have been made. Phytochemical analyses of the plant have shown the presence of several alkaloids, both water-insoluble bases and water-soluble quaternary ammonium salts. The major constituent of the bases is a tertiary diterpenoid alkaloid, methyllycaconitine (Aiyar et al. 1979).

(c) *Phenology: D. glaucum* emerges soon after the ground is fully thawed, but averages about 14 days later in appearance than *D. bicolor* where the two species occur in the same area. Observations in the Rocky Mountains and boreal forest areas over a period of several years showed that emergence of plants in "average" years occurs in the first half of May. Plants in the southern part of the range appear about eight days earlier than those in the northern part. Vegetative growth is rapid, but flowering stems do not usually reach full development until mid-June. In this stage, too, plants in the south reach flowering earlier than those in the north. Thus, in Alberta, plants in the Waterton area had fully developed flowering stems, still in the bud stage, on 6 June; stems on plants west of Nordegg had not yet fully developed on 8 June, and north of Hinton on 9 June. Stems were somewhat farther advanced, but not in bud-stage, in the Peace River district on 10 June. However, by the middle of July plants throughout the area of distribution were in full flower. A much less pronounced delay in development was observed with increasing altitude. The flowering period lasts until the first killing frost: I have collected plants in flower in late September at 1600 m altitude in the Rocky Mountains, where temperatures of – 2°C prevailed during the night.

Stamens mature in part before flower buds open completely, and pollen is shed soon after the flowers are expanded. Pistils mature somewhat later, after all stamens in the flower have shed their pollen. The flowering sequence on a single stem is such that unopened buds and ripening follicles are often present (Figure 3). Because several stems may develop in succession during the flowering period undeveloped stems as well as mature ones on which seed has ripened, can be present on a single plant. Follicles on the late-appearing stems seldom reach maturity. From anthesis to maturity of the seed requires about 50 days; observations on plants in Swift Current over eight years showed a range of 42 days in dry, warm years to 56 days in cold, wet years.

7. *Reproduction*

(a) *Floral biology:* Tall Larkspur is insect pollinated. Pollination is open, and cross-pollination between flowers on the same stem occurs, but results in very poor seed set. In several isolated plants I found that more than 90% of the ovules had aborted. Cross-pollination between plants results in much better seed production, particularly in the early part of the season, i.e., June-July.

(b) *Seed production and dispersal:* Counts on 50 plants in the Rocky Mountains and southern boreal forest area showed an average of 3.7 ± 1.1 stems per plant, with a range of 1–8 stems. However, 26 of the plants had a range of 3–6 stems, accounting for 65% of the total number of stems. The number of flowers ranged from 21–77 per stem, averaging 54.4 ± 10.9 flowers per stem. There appeared to be a tendency towards a larger number of

FIGURE 6. Seedlings: above left and below right, one-year old collected in October 1976; above right and below left, two-years old, October 1977. About 0.75 × actual size.

flowers per stem on plants with several stems. Thus, the average number of flowers per stem on single-stemmed plants was 23.8 ± 1.1, that on two plants with eight stems each was 67.7 ± 2.9. The main reason for this increase in numbers of flowers seemed to be that, with increasing size of the plants, stems tended to form several flowering branches.

The average number of ovules per follicle in 2775 follicles was 17.3 ± 3.3, with a range of 10–21. Thus, *D. glaucum* has a potential seed production of more than 10,000 seeds per plant. However, this potential is probably seldom reached; the number of abortive ovules is high, reaching 70% in some plants; particularly on the stems produced in August and later. Usually, late summer and fall do not allow enough time for fertilized ovules to ripen, and often pollination is very poor. Prolonged wet periods can cause poor pollination in summer, particularly in June, the wettest month of the growing season in most of the area of distribution.

Mature follicles remain on the stems, and seeds are dispersed by the wind or animals disturbing the stems, causing the ripe seeds to be shaken out of the opened follicles. Most of the seeds are likely to fall close to the parent plant, but I have found seedlings as far as 25 m from the nearest plant with the direction of prevailing winds.

(c) *Seed viability and germination:* Viable seed collected in the year of production and stored dry at room temperature does not germinate without treatment. Moist stratification at 0 to –5° C resulted in 20–30% germination at 0 to 5° C, and 40–45% germination at 5–10° C. In Swift Current, germination of seed dispersed in summer and fall in the garden occurred when air temperatures reached 7–10° C in early May. The percentage germination was low. Estimating the seed production of three plants at about 15 000 seeds, based on the number of follicles produced, fewer than 2000 seedlings appeared. In the natural habitat germination is even lower, probably amounting to less than 1% of the potential seed production as estimated from the number of plants and follicles produced. Seed retains viability for at least four years in dry storage at 0° C, and in the soil for at least two years.

(d) *Vegetative reproduction: D. glaucum* produces new stems from root buds each year, and the number of stems increases with age, reaching a maximum of 6–8 stems, 5–7 years after the first flowering stem is produced. Damage to the root system, resulting in splitting of the roots, can lead to the production of two or more complete plants. However, vegetative reproduction appears to play a minor role in maintaining the status of populations, and does not significantly contribute to increasing density.

8. *Population Structure and Dynamics*

(a) *Density and dispersion pattern:* Counts in 18 semi-open grassland stands where the species occurred with considerable abundance, showed a density of about 25 plants per 100 m^2, with a range of 2–73 plants/100 m^2. Counts in 20 forest margins, both aspen and coniferous, showed an average density of about 10 plants/100 m^2, with a range of 0.4–31 plants/100 m^2. In 12 willow thickets average density was 11 plants/100m^2, with a range of 0.2–47 plants/100 m^2. The density found in open woods was very low, in the order of 4 plants/100 m^2. All counts were made on a total area of at least 600 m^2.

The species shows a trend towards increasing density from the southern Rocky Mountains towards the north, with the greatest densities noted in northcentral Alberta.

Tall Larkspur populations are usually of too low a density to show a well defined dispersion pattern. Although the plants are usually randomly distributed within the area of their occurrence, their limitation to the margins of woods and thickets may be seen as aggregation. Hence, the pattern found depends largely on the manner in which the population is sampled, as well as the manner in which the habitat of the species is defined. If the species is considered to be characteristic for "Saumgesellschaften" (margin-communities) (Dierschke 1974), without considering its position and distribution within the woods in the margins of which it occurs, the distribution pattern is almost always random, with a tendency towards aggregation at both very low and very high densities.

(b) *Age distribution:* The age of plants of *D. glaucum* in natural populations cannot be accurately determined. However, based on the development of seedlings (section 6(a)), it is possible to obtain an approximation of various ages if it is assumed that plants observed have developed without disturbance. Thus, plants with 2–5 leaves can be classed as "young" (two or three years old); those with more than 5 leaves but not yet developing flowering stems as "immature" (four to six years), those with a single flowering stem as "mature" (six to eight years), and those with 3 or more flowering stems as "old", more than eight years old. Counts of seedlings in semi-permanent quadrats in three areas of the Rocky Mountains (see 2(h)) as well as in the garden at Swift Current, showed a very low survival rate of seedlings, in the order of 0.1%, from germination in May until late

July. The most common cause of seedling mortality is probably lack of available space, i.e., competition. Young and immature plants form a small part of the population; the average density of these plants in semi-open grassland where density counts were made was about 1.5 plants per 100 m^2, or about 6% of the average density of Tall Larkspur.

(c) *Size distribution:* Once plants have reached maturity, and flowering stems are produced, there is no longer any correlation between size and age. Although plants in the garden showed an increase in number of flowering stems with increasing age, in the natural habitat plants are often damaged, and it was usually only possible to distinguish between young plants, with one or two flowering stems, and old ones with five or more flowering stems. Similarly, there is no apparent correlation between the age of plants and height of flowering stems. These may reach 150 to 200 cm in young plants as well as in old ones.

The mass of plants is directly related to size, both basal area and height, and varies with several factors, as moisture, temperature, and shading. Plants in open grassland and full shade produce less mass than those in the margins of woods and shrub or shrubby grassland. Above-ground dry matter production of well developed plants may reach 15 g or more.

(d) *Growth and turnover rates:* The growth rate of plants in a given year depends largely on the prevailing weather conditions. Although soil moisture conditions are usually good early in the growing season, drought in late May and June prevents normal development. Similarly, very cold weather can severely retard growth in the early part of the growing season. Given favourable weather conditions, growth of the plants is rapid. Measurements on plants in marked areas of 625 m^2 (see 2(h)) showed a growth in height from less than 10 cm in late May to 80–95 cm in mid-July, when flowering stems reached early development, i.e., preflowering stage. Fresh weight of the plants had increased from about 1.5 g/plant to about 55 g/plant, averaging two plants per area. The growth rate from year to year in natural populations is difficult to estimate. Marked plants often are damaged, either by trampling, or falling branches, and also have a tendency to "creep" on the root system, causing uncertainty about the identity of the plant when sites are not visited every year. However, assuming that the growth rate of plants in Swift Current can be compared to that of plants in the natural habitat, growth is very rapid during the first three years, but thereafter slows down. Thus, a four-year old plant can reach a weight of 50 × that of the seedling, but an eight-year old plant weighs only a little more than 3 × as much as a four-year old plant. The optimum weight is reached at the time of full flowering; the heaviest plant found in nature, near Clear Hills, Alberta, had six flowering stems and a dry weight of 15.6 grammes.

Observations in the marked areas showed no replacement of mature flowering plants over a period of five years. During that period two immature plants reached the flowering stage in each of two stands, with one immature plant reaching that stage in a third stand. Turnover, therefore, appears to be slow.

(e) *Successional role:* Tall Larkspur is usually a minor component of the vegetation where it occurs. Its successional role in the natural habitat is, therefore, also minor, and its major contribution is probably a certain amount of organic matter. Because the species occurs almost exclusively in grassland-forest transitions, it may be considered an indicator of potential forest vegetation.

9. *Interaction with Other Species*

(a) *Competition:* In undisturbed habitats, where the plant community is in biological equilibrium, species are in balance with the habitat and each other, competition is at a minimum (Looman 1976), and *D. glaucum* appears to maintain its position in the vegetation cover. In severely disturbed habitats, as in cutover areas and secondary forest development, the species can become abundant because of its high seed production and longevity.

(b) *Symbiosis:* In more than 300 observations of pollination throughout the Rocky Mountains and Peace River district the most frequent visitors were bumble bees (*Bombus* spp.), with about 75% of the visits. The second most frequent visitors were Honey Bees (*Apis mellifera*), with about 23% of the visits. The remaining visits were by flies, a butterfly and a moth, and were probably accidental rather than intentional, because the flowers were not entered. Visits by both bumble bees and Honey Bees were invariably very brief.

No evidence of mycorrhiza or other forms of symbiosis have been found or reported.

(c) *Predation and parasitism:* A few plants were seen on which aphids (*Aphididae*) were feeding, but no other insect damage has been observed. However, in a few plants empty pupae, probably those of a small wasp, were found attached between the follicles. No evidence of utilization by small mammals has been seen.

On several plants fungal infestations were found on the leaves. One fungus belonged to the *Uredinales,* but was insufficiently developed for further determination. A second fungus had numerous pycnidia in various stages of development, and immature spores indicate that this fungus may belong in the genus *Diplodia.* No

further determination could be made, and it is not known whether the organisms are host or genus specific.

Conners (1967) lists several fungal, bacterial, and viral parasites of *Delphinium*, mainly on garden plants. Garden specimens in Swift Current are affected by powdery mildew, *Fusarium* sp., *Botrytes* sp., and crown and/or root rot. I have seen no evidence of their occurrence in the natural habitat, nor on herbarium specimens.

Domestic cattle, sheep, and deer occasionally graze on Tall Larkspur, especially in early stages of growth when the plants are succulent and much of the other vegetation is still dormant.

Cutworms (larvae of Noctuidae) and wireworms (larvae of Elateridae) may be found feeding on the root system; some species of cutworm have been found feeding on the young stems of inflorescences.

(d) *Toxicity and allelopathy:* Because of their very poisonous properties, Tall Larkspurs have caused considerable losses of livestock in most areas where they occur (e.g., Dayton 1960; Marsh et al. 1934; Looman et al. 1983). The important poisonous principle in Tall Larkspur was formerly held to be the diterpenoid alkaloid delphinine commom to species of *Delphinium* and *Aconitum* (Kingsbury 1964), but is now known to be methyllycaconitine (Aiyar et al. 1979). Toxicity varies with the season, amount ingested, and length of time in which ingested, as well as with the species of *Delphinium* and the species of animal. In spring, when the lush foliage is very toxic, as little as 0.7% of an animal's body-weight in plant material ingested can be fatal (Looman et al. 1983; Kingsbury 1964). At flowering and at maturity, toxicity is much decreased, but the seeds are highly toxic. Symptoms of poisoning are similar to those produced by Low Larkspur (Looman 1975): abdominal pain, nausea, depressed respiration, and eventually asphyxiation.

The small amount of young plant material needed to supply the lethal dose of poison — only about 2 kg for an average yearling, about 3.5 kg for a mature cow — makes the density of *D. glaucum* on the range very important. In the southern Rocky Mountains, the fresh foliage of a plant in the preflowering stage weighs 55 g (average of 20 plants). At an average density of 4 plants/100 m^2, an animal must graze 2000 m^2 to ingest the lethal dose, and this may be ingested by an animal in a short period of time. Farther north, where the species becomes more common, and at the same time often more vigorous, the area on which the lethal amount of plant material can be grazed is often reduced to 1500 m^2, or even 1000 m^2. However, in these areas Tall Larkspur usually forms a much smaller part of the fresh forage than in more southern areas. Generally, poisoning through Tall Larkspur is less common than might be expected, primarily because of its relatively low density.

Tall Larkspur is poisonous to all domestic animals. Horses have been poisoned experimentally, but seldom ingest lethal amounts under natural conditions. Sheep, although not entirely immune, are little affected and have been used to graze off the larkspur plants on infested range before bringing in cattle. The sheep also trample many plants, but this method is not entirely satisfactory (Marsh et al 1934). It seems likely that the elk (Wapiti: *Cervus canadensis*) is affected. In three separate areas I have seen recently dead animals in the immediate vicinity of vigorously growing plants of Tall Larkspur showing signs of usage. In the northern lowlands the "buffalo" (*Bison bison*) probably suffers occasional losses through poisoning by Tall Larkspur.

Insects and insect larvae feeding on plant parts, including the seeds, do not seem to be adversely affected. It is possible that the digestive system of insects and their larvae inactivates the toxic substances. Nestling robins, fed wireworms and cutworms that had been feeding on larkspur roots, developed normally without apparent ill effects. No indications have been observed that birds consume seeds of Tall Larkspur.

No indications of allelopathic influence on other plant species have been observed or reported.

10. *Evolution and Migration*

No accounts of evolution of phylogeny of *D. glaucum* have been seen. It is likely that the species migrated northeastward and, after reaching the interior mountain ranges, northward from areas in the western mountain ranges of the United States, after retreat of the glaciers at the end of the Pleistocene. Its absence from the Coastal Mountains in British Columbia may then be explained by the barrier posed by the Juan de Fuca Strait, combined with prevailing winds.

The present distribution appears to be somewhat more limited than before arrival of settlers in western Canada. Locally, it appears to have been eradicated, or nearly so, through clearing and cultivation of its native habitat, the aspen and willow groves. Early collections have been made as far east and south as Carleton, Saskatchewan, as reported by Macoun (1883).

11. *Response Behavior*

(a) *Fire:* as a constituent of the vegetation of forest margins and shrubbery, *D. glaucum* may be occasionally subjected to burning. Its root system appears to survive fires, unless the fire is slow burning and hot. In several burned-over areas high densities of mature as well as immature plants were observed. Thus, in the Clear Hills,

Alberta, a burned area, previously aspen woods, with a very low density of Tall Larkspur, had a high density of immature plants five years after the fire; most of the mature plants appeared to be survivors of the fire. Similarly, the density of Tall Larkspur had greatly increased after five years where aspen trees had been cut.

(b) *Grazing and harvesting:* Although poisonous, plants of Tall Larkspur are palatable, that is, tasty to some animals, shortly after growth commences in spring, and grazed to some extent. Later in the season plants become coarse and are no longer palatable. On plants which have been grazed, or otherwise damaged, the inflorescences may consist entirely of axillary branches. Overgrazing of range containing Tall Larkspur can lead to great increases in the density of the species, and therewith the problem of stock poisoning. Continued overgrazing, however, causes drought-like conditions and can result in disappearance of Tall Larkspur.

(c) *Flooding:* The habitat of *D. glaucum* is not normally subject to prolonged flooding during the growing season. Some willow-thickets in which it was found showed indications of prolonged flooding before the beginning of the growing season, and still had a very high ground water table in mid-June, apparently without adverse effects on the larkspur plants. The species can also withstand brief periods of flooding after heavy summer rains, which may last two or three days.

(d) *Drought:* In most of the area of its occurrence, *D. glaucum* is not usually subjected to severe drought. It can survive dry periods of two to three weeks, during which growth and development are slowed down. Dry periods of longer duration did not occur during the years in which the species was studied.

Based on the nature of its habitats and the accompanying vegetation, as well as its abundance, *D. glaucum* can be classified as mesophytic. Placing the species on a synthetic moisture gradient devised for grasslands in Saskatchewan (Looman 1963), but extending it to include the habitats of *D. glaucum*, its range of tolerance for moisture conditions can be estimated as skewed towards wet-mesic conditions.

(e) *Herbicides*

Tall Larkspur can be eradicated by means of several herbicides, including 2,4-D in ester or amine form, MCP, and Dicamba with one of the foregoing, but only when applied very early in the growing season, and repeated after new shoots appear. Because of its occurrence in grassland-forest transition, use of herbicides is usually impractical.

(f) *Chemical changes: D. glaucum* grows primarily on soils low in phosphorus and nitrogen, and fertilization of the soil with N-P fertilizer has an adverse effect on the species (see 4(c)). This may well indicate that *D. glaucum* is "nitro- and phosphoro-phobic". According to the work of de Vries and Dijkshoorn (1961), plants showing the phenomenon of "phoby" for one or more nutrients take up the nutrient concerned very easily or rapidly, which may cause an imbalance in the ratio of the plant's needs.

(g) *Frost:* Tall Larkspur grows in areas where temperatures drop to –50° C and lower without being adversely affected. Low temperatures in the early growing season slow its development, but normal growth is resumed as soon as temperatures return to average for the season.

Plants occurring at low altitudes, i.e., below about 500 m, appear to grow taller than those at high altitudes. However, it seems unlikely that this is due to the effect of temperatures, but may be due to the greater incidence of ultraviolet light with increasing altitude. Also, the climatic conditions at high altitudes and short season may play an important role. It may be noted that the stems of plants in the garden at Swift Current show a similar reduction in height, and seldom reach more than 75 cm.

12. *Relationship to Man*

The highly toxic properties of Tall Larkspur make the species undesirable in range used for grazing domestic cattle. Its abundance in moderately grazed range does not reduce forage yields appreciably, and deferment of grazing until plants reach the flowering stage reduces the danger of stock poisoning.

Tall Larkspur has considerable merit as an ornamental plant which flowers from summer until fall in semi-shaded moist areas. It was used as an ornamental by many of the early settlers in the parklands where it occurred naturally. In areas where the species is now very rare or has been entirely eradicated, plants can still be found in abandoned gardens.

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Appendix 1. Areas in which stands of vegetation with *Delphinium glaucum* were studied and soil samples taken.

Locality	Latitude	Longitude	Species lists*	Soil samples*
Alberta				
Waterton Lakes National Park	49°00-05′N	113°40′W	S 6, A 5	S 2, A 3
Drywood Mountain	49°15-17′N	114°03′W	S 6, A 6	S 3, A 5
Beaver Mines Lake	49°20-25′N	114°15-20′W	S 3, A 4, P 3	S 3, A 2, P 2
Racehorse Creek	49°40′- N	114°25-30′W	S 3, P 2	S 2, P 2
Plateau Mountain	50°10-15′N	114°30-35′W	S 4	S 2
Highwood River	50°25-27′N	114°45′- W	S 6	S 2
Meadow Creek	51°20-25′N	115°00-04′W	S 2, A 3	S 1, A 1
Burnt Timber Creek	51°30-35′N	115°10-15′W	A 3	
Red Deer River	51°37-45′N	115°10-20′W	S 4, A 3	S 2, A 1
James River	51°50′- N	115°10-15′W	S 2, A 4, P 3	S 1, A 1, P 1
Clear Water River	52°03-05′N	115°32-35′W	A 4, P 3	A 1, P 1
Thompson Creek	51°58′-52°N	116°40-45′W	P 4	P 2
Nordegg	52°25-32′N	116°05-15′W	A 4, P 4	
Cline Creek-Pinto Lake	52°05-10′N	116°45-52′W	N 4	N 4
Whirlpool River	52°42-45′N	117°55-60′W	N 2	N 2
Jasper National Park	52°40-45′N	118°00-05′W	P 3, W 2	
Jasper N.P.: Celestine Lake	53°05-13′N	118°00-05′W	P 2, W 2	
McLeod River	53°05-10′N	117°05-15′W	P 4	P 2
Cache Lake	53°22-27′N	117°40-45′W	P 3, W 2	P 2, W 1
Eureka River	56°25-30′N	118°40-45′W	W 4	W 2
Worsley	56°30-35′N	119°00-05′W	W 2	
British Columbia				
Charlie Lake	56°18-23′N	120°55-121′W	W 2	
Keg River	57°45-50′N	117°35-40′W	W 3	W 1
Trutch area	57°40-45′N	122°55-123′W	W 2	W 1
Muncho Lake	59°00-03′N	125°45-47′W	W 2	W 1

*S = Southern Prairie; N = Northern Prairie; A = Aspen groves; P = Pine forest; W = Willow thickets.
Numbers of lists and representative soil samples is indicated.

Notes

Effects of Various Hardwood Forest Management Practices on Small Mammals in Central Nova Scotia

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Small mammals were trapped in a northern hardwood forest in Nova Scotia that had been subjected to the following treatments: (1) clearcutting, (2) strip-cutting, (3) shelterwood cutting, plus (4) uncut controls. No significant differences in the overall abundance of small mammals were observed between treatments. *Clethrionomys gapperi* was the most frequently captured species on all sites. *Blarina brevicauda* and *Sorex cinereus* were somewhat less abundant, but they occurred on all sites. *Microtus pennsylvanicus* was generally more abundant on stripcuts and clearcuts where favourable habitats of wetland and grass and sedge were created. *Peromyscus* spp. were more abundant on shelterwood cuts.

Key Words: small mammals, abundance, hardwood forest, silviculture

Forest harvesting practices radically affect soils and vegetation, and these habitat changes necessitate adjustments by all wildlife which occur on the site. Few studies have investigated the responses of small mammals (i.e. mice, voles, and shrews) to harvesting practices, largely because these animals are not generally considered to be of economic importance. However, the natural regeneration of the forest may be directly affected by small mammal browsing and seed predation. In some cases, they have been considered responsible for the failure of predicted regeneration patterns following artificial or natural seeding (Smith and Aldous 1947; Harris 1968; Hooven 1975; Sullivan 1979).

Hamilton and Cook (1940) suggested some beneficial ecological roles of small mammals. The burrowing activities of some species loosen the soil, aiding air and water movement, as well as mechanically mixing litter and topsoil. Insectivorous mice and shrews may help to control some forest insects. Small mammals serve as a food source for predatory mammals of economic importance to the fur industry such as bobcat or weasel, and they may function as a buffer, by decreasing predation on Ruffed Grouse and other woodland game. Finally, small mammals may serve as vectors for the dispersal of plant seeds and mycorrhizal fungi.

The present study has examined the changes in abundance and species composition of small mammal communities following various hardwood forest harvesting practices in central Nova Scotia, an area where such studies have not previously been conducted.

Methods

The study plots, all located within 3 km of each other, were in Kings County, Nova Scotia, near 44°55′N latitude, 65°44′W longitude. The forest originated following a fire approximately 80 years ago, and is now dominated by hardwood species, especially Red and Sugar Maple (*Acer rubrum* and *A. saccharum*), and White and Yellow Birch (*Betula papyrifera* and *B. alleghenensis*). Three 3 to 5-year old clearcuts, two 3 to 5-year old shelterwood cuts, five 3-year old stripcuts, and three uncut forest stands were selected for small mammal trapping. The clearcut plots had an average (± S.D.) area of 3.6 ± 0.4 ha, a shrub stem density of 29 900 ± 6600 stems/ha, and a ground vegetation cover of 130 ± 36%. The shelterwood plots had an average area of 1.9 ± 0.1 ha, a tree stem density of 290 ± 170 stems/ha, a tree stem basal area of 9.4 ± 3.9 m^2/ha, a shrub stem density of 28 000 ± 13 000 stems/ha, and a ground vegetation cover of 145 ± 15%. The stripcut plots had an average area of 4.6 ± 1.7 ha, a shrub stem density of 34 900 ± 5700 stems/ha, and a ground vegetation cover of 170 ± 10%. The uncut forest plots had an average area of 4.1 ± 1.1 ha, a tree stem density of 1700 ± 200 stems/ha, a tree stem basal area of 25.9 ± 4.4 m^2/ha, a shrub stem density of 4300 ± 2100 stems/ha, and a ground vegetation cover of 62 ± 10%. More detailed

descriptions of the plant communities on these sites are given in Freedman et al. (1981).

Each area was sampled using snap traps. Prior to each sampling period, duplicate traps were placed at 15 m intervals along one 300 m transect per plot, and were baited with a mixture of oatmeal, raisins, peanut butter, and bacon grease. Traplines were located at least 30 m from the nearest habitat edge for all treatments except the 20 m-wide stripcuts, where the minimum distance was 10 m. The traps were baited but not set for the first two nights, and then trapping was carried out for five consecutive nights (the traps were checked daily). There were four trapping intervals in 1980: A) 16–22 July; B) 24–30 July; C) 30 July–4 August; and D) 3–9 August. All plots were trapped at least once, and on some trapping was repeated. Relative species abundance was calculated as numbers trapped per 100 trap-nights.

Results and Discussion

The results of this study indicate that the forest manipulations we examined did not significantly affect the overall abundance of small mammals (Table 1; heterogeneity was tested by chi-square, $p > 0.05$). However, there were notable changes in the abundance of certain species. For example, *Microtus pennsylvanicus* (Meadow Vole) abundance was greater on clearcuts and stripcuts where favourable patches of wet habitat with *Sphagnum*, and areas with sedges and grasses were created. *Clethrionomys gapperi* (Boreal Redback Vole) was generally the most abundant species, and was captured consistently on all plots. *Blarina brevicauda* (Shorttail Shrew) and *Sorex cinereus* (Masked Shrew) were somewhat less abundant, but they occurred on all habitat types. The greatest abundance of *S. cinereus* was on clearcuts. *Tamias striatus* (Eastern Chipmunk) captures were infrequent, so that generalizations about this species cannot be made. *Peromyscus* spp. (Deer Mice) were captured most frequently on the 3-year old shelterwood cut, which had less ground and shrub cover than the 5-year old shelterwood and the other sites. Martell and Radvanyi (1977) made similar observations, i.e. relatively high abundance of *Peromyscus* on recently cut sites. Miller and Getz (1977) positively correlated the abundance of *Peromyscus* spp. with debris cover, and negatively correlated it with vegetation cover.

Napaeozapus insignis (Woodland Jumping Mouse) was trapped consistently only on stripcuts, suggesting a preference for open areas bordering on forest. Kirkland (1977) pointed out that this species prefers herbaceous cover, which was prevalent on all stripcuts. *Napaeozapus insignis* was also relatively abundant on uncut site 1 and on shelterwood site 2, but only during

TABLE 1. Relative abundance of small mammals in areas affected by various forest harvest practices. The three uncut stands were in a mature maple-birch forest. Clearcuts 1 and 2 were three years old, while clearcut 3 was five years old. All five stripcuts were three years old. Shelterwood cut 1 was three years old, while shelterwood cut 2 was five years old. All data are in numbers of captures per 100 trap-nights. Sampling period A was 18–22 July; B was 26–30 July; C was 1–4 August; D was 5–9 August.

	Uncut Control						Clearcuts					
Species	1A	2B	2D	3B	3D	$\bar{x}$	1A	2A	2D	3B	3D	$\bar{x}$
Blarina brevicauda	5.6	1.0	7.5	1.0	4.5	3.9	2.0	5.0	6.5	0.0	3.5	3.4
Sorex cinereus	0.0	1.5	3.0	2.5	4.0	2.2	4.0	5.5	2.5	5.0	7.5	4.9
Clethrionomys gapperi	8.1	4.0	6.0	7.0	10.0	7.0	10.5	3.0	3.5	6.5	6.5	6.0
Peromyscus sp.	0.6	0.5	0.5	1.0	2.5	1.0	0.5	0.0	0.0	0.0	3.0	0.7
Microtus pennsylvanicus	0.6	0.0	0.5	0.0	0.0	0.2	0.0	5.5	2.0	0.0	6.5	2.8
Tamias striatus	0.0	0.5	0.0	0.5	0.0	0.2	1.0	0.0	0.0	0.0	0.0	0.2
Napaeozapus insignis	11.9	0.0	0.5	0.0	2.0	2.9	0.5	0.0	1.0	0.0	0.0	0.3
TOTAL	26.8	7.5	18.0	12.0	23.0	17.4	18.5	19.5	15.0	11.5	27.0	18.3

	Strip-cuts						Shelterwood				
Species	1B	2B	3C	4C	5C	$\bar{x}$	1A	1D	2A	2D	$\bar{x}$
Blarina brevicauda	4.7	0.7	3.5	1.5	2.0	2.5	1.5	5.0	2.0	5.0	3.4
Sorex cinereus	1.3	2.7	5.5	0.5	1.0	2.2	2.5	2.5	1.5	2.5	2.3
Clethrionomys gapperi	6.0	5.3	3.0	5.5	4.5	4.9	9.0	4.2	5.5	0.8	4.9
Peromyscus sp.	0.0	0.7	0.5	0.0	1.0	0.4	5.5	4.2	1.5	0.8	3.0
Microtus pennsylvanicus	0.0	6.7	0.0	5.0	1.5	2.6	0.5	0.0	1.0	0.8	0.6
Tamias striatus	1.3	0.7	0.0	0.5	1.0	0.7	0.0	0.0	1.5	0.0	0.4
Napaeozapus insignis	1.3	5.3	5.0	1.0	2.0	2.9	0.5	0.8	17.5	0.0	4.7
TOTAL	14.6	22.1	17.5	14.0	13.0	16.2	19.5	16.7	30.5	9.9	19.3

one of the trapping periods (16–22 July). During another trapping period (3–9 August) both of these sites were resampled, but no captures of *N. insignis* were made.

A similar dramatic change between trapping periods occurred for overall abundance on uncut stands 2 and 3 and clearcut 3. All of these sites were trapped during period B (24–30 July), and again during period D (3–9 August). Overall abundance on these sites increased by a factor of 2–3 between these periods (Table 1). Most species remained the same or increased in abundance; none decreased except *Tamias striatus,* which was only infrequently captured. Two other sites (shelterwood cuts 1 and 2) were also trapped during period D, but the small mammal abundance did not vary dramatically. The large difference in abundance between sampling periods emphasizes the fact that populations of small mammals can fluctuate substantially over short time periods.

The general results of this study are in agreement with those of Krull (1970), who suggested that the abundance of small mammals in northern hardwood sites in New York changed substantially and unpredictably over a 10-year period, and was essentially independent of clearcutting. Other researchers have also documented this phenomenon (Sheldon 1936; Hamilton and Cook 1940; Jameson 1955).

Other studies have found rather different responses of small mammals to hardwood management. Kirkland (1977) trapped small mammals in hardwood forests and clearcuts in the northern Appalachians, and found an increase in overall abundance in the clearcuts. Another study (Martell and Radvanyi 1980) in northern Ontario investigated a mixedwood stand where conifers had been selectively thinned. These authors also found an overall increase in the abundance of small mammals compared to controls. Hahn and Michael (1980) conducted a two-year study on uncut hardwood forests and whole-tree clearcuts in West Virginia. In the first post-cutting year they found no significant change in the abundance of small mammals, but in the second year they found a small but significant decrease in the whole-tree clearcuts.

In conclusion, we found few changes in overall abundance or species composition of small mammals in the harvest treatments that we examined, in spite of great changes in habitat. In view of these observations, the conflicting data in the literature, and the inherent temporal variations in small mammal abundance, generalizations relating hardwood forest management, small mammal abundance and species distributions cannot be made.

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Parasites of the Knifenose Chimaera, *Rhinochimaera atlantica*, from the Northwest Atlantic Ocean

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Two species of digenetic trematodes (*Opecoloides vitellosis* and *Lecithocladium gulosum*), two species of cestodaria (*Gyrocotyle abyssicola* and *Gyrocotyle major*) and one species of ascaridoid nematode (*Hysterothylacium aduncum*) were recovered from two Knifenose Chimaeras (*Rhinochimaera atlantica*) collected in the northwest Atlantic Ocean.

Key Words: *Rhinochimaera atlantica*, parasites, northwest Atlantic Ocean.

Three species of chimaerid fishes inhabit the deep waters of the northwest Atlantic Ocean (Leim and Scott 1966). *Harriotta raleighana* Goode and Bean, 1895, *Hydrolagus affinis* Capello, 1868, and *Rhinochimaera atlantica* Holte and Byrne, 1909, have been collected at a depth range of 550 to 1100 m. All three species are rarely caught and their biology is virtually unknown. Only one study has reported on the parasites of these fishes. Land and Templeman (1968) described two new species of *Gyrocotyle* Diesing, 1850, from the spiral valve of *H. affinis* collected off the Grand Banks of Newfoundland.

Two specimens of the Knifenose Chimaera (*Rhinochimaera atlantica*) were collected by experimental deep-water trawl in 1100 m of water off the Scotian Shelf during November of 1982. The fish were frozen whole at sea and later thawed, dissected and examined for parasites in the laboratory in December 1982. Whole mounts of digeneans were stained in Grenachers' alum carmine or Semichons' carmine. Rosettes of cestodaria were cleared in a 1:9 solution of glycerin and 70% ethanol or Berlese fluid and mounted in glycerin jelly. The remaining portions of the worms were stained in Blachins' lactic acid carmine. Nematodes were cleared in 85% lactic acid.

The species and number of specimens of each recovered during the present survey were as follows:

Digenea
- *Lecithocladium gulosum* Linton, 1901; 1
- *Opecoloides vitellosis* Linton, 1901; 4

Cestodaria
- *Gyrocotyle abyssicola* Land and Templeman, 1968; 4
- *Gyrocotyle major* Land and Templeman, 1968; 2

Nematoda
- *Hysterothylacium aduncum* Punt, 1941; 3

The digenean *O. vitellosis*, has been reported from several species of marine fishes in the northwest Atlantic Ocean. Linton (1901) recovered *L. gulosum* from inshore fishes collected at Woods Hole, Massachusetts. Digenea have not previously been reported from chimaerid fishes. Three adult *H. aduncum* were found in the spiral valve of one fish examined. This is the first report of nematodes in chimaerid fishes.

Specimens deposited in the Atlantic Reference Collection, Department of Fisheries and Oceans, Biological Station, St. Andrews, New Brunswick E0G 2X0, are as follows: *Opecoloides vitellosis*, cat. no. 2406; *Lecithocladium gulosum*, cat. no. 2407; *Gyrocotyle abyssicola*, cat. no. 2408; *Gyrocotyle major*, cat. no. 2409; *Hysterothylacium aduncum*, cat. no. 2151.

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Abnormal Dentition in the American Bison, *Bison bison*

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Van Vuren, Dirk. 1984. Abnormal dentition in the American Bison, *Bison bison*. Canadian Field-Naturalist 98(3): 366–367.

Three of 27 Bison (*Bison bison*) examined in the Henry Mountains, Utah, had supernumerary teeth, and a fourth animal lacked a tooth. In addition, a Bison collected near Delta Junction, Alaska, had a supernumerary tooth. All five instances of abnormal dentition were from herds founded with few individuals, suggesting the influence of inbreeding and genetic drift.

Key Words: *Bison bison*, abnormal dentition, supernumerary teeth, inbreeding, genetic drift

From 1977 through 1983 I examined 27 carcasses from a herd of 200–350 wild Bison (*Bison bison*) in the Henry Mountains, Garfield County, Utah, and found four with supernumerary or missing teeth. One animal was 2 years old, based on tooth eruption (Frison and Reher 1970), and had a normally shaped, supernumerary P_3 situated in the tooth row between the left P_3 and P_4; both deciduous and permanent forms of all three teeth were visible (Figure 1). An infection, probably *Fusobacterium necrophorum* (T. P. Kistner, personal communication), had caused a bony enlargement of the dentary below the supernumerary tooth. It is unclear whether the infection resulted from the extra tooth or was associated with the cause of the extra tooth. The second and third animals, each 3 years old, had supernumerary teeth that were similar in several ways; both teeth were deformed, possessed a single, protruding style, and extended posteriorly along the lingual side of the tooth row. The tooth of one of these animals originated between the bases of the right M_1 and M_2 (Figure 2), and the tooth of the other animal originated at the base of the right P^3. The fourth animal, at least 5 years old, lacked the right P_2; the left P_2 was reduced and peg-shaped, 7 mm in diameter and protruding 12 mm above the dentary. There was no evidence that abnormal dentition contributed to the death of these animals; all four were killed by hunters.

Among 211 museum specimens of modern Bison from 63 other locations throughout much of North America, I found one with a supernumerary tooth. It was collected in 1943 near Delta Junction, Alaska, and was at least 5 years old. The tooth was deformed, as were two of three supernumerary teeth from the Henry Mountains sample, but did not have a protruding style. It was situated beside the right P^3 on the lingual side of the tooth row, a location identical to that of one of the teeth from the Henry Mountains sample.

Supernumerary teeth may result from reappearance of phyletically suppressed teeth or from appearance of new teeth that exceed the primitive number (Steele and Parama 1981). Published information on dental anomalies of modern Bison apparently is limited to two individuals with a vestigial P_1 (Fuller 1954), a phyletically suppressed tooth. The Bison

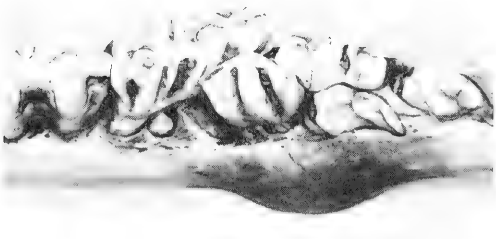

FIGURE 1. Supernumerary P_3, between the normal P_3 and P_4, in a Bison from the Henry Mountains, Utah.

FIGURE 2. Supernumerary tooth, originating between M_1 and M_2 and extending posteriorly along the inside of the tooth row, in a Bison from the Henry Mountains, Utah.

reported here are the first for which either missing teeth or supernumerary teeth in excess of the primitive number have been described. To my knowledge the frequency of supernumerary teeth from the Henry Mountains sample (11%) is the highest recorded for wild ungulates. Steele and Parama (1981) reviewed the literature on the occurrence of supernumerary teeth in North American Bovidae and Cervidae and found that frequencies of teeth that exceeded the primitive number ranged from 0.08% to 7.5%. Colyer (1936) reported 18 occurrences of supernumerary teeth in 2284 specimens of various wild Artiodactyla (0.8%), and deCalesta et al. (1980) reported 2 of 6663 Black-tailed Deer (*Odocoileus hemionus columbianus*) with supernumerary teeth (0.03%).

Wilson (1974) and McDonald (1981) reported supernumerary teeth and other dental anomalies among specimens of extinct subspecies of Bison and attributed them to inbreeding and genetic drift in small populations. Inbreeding led to changes in number and size of teeth in laboratory mice (Gruneberg 1951). Similar processes may have caused the dental anomalies reported here. The Henry Mountains herd was founded with 8 bulls and 15 cows released in 1941 and 1942 (Winn and Collett 1959). Three of the bulls vanished before their first rut, and so the herd is descended from at most 5 bulls and 15 cows. The Alaska herd was founded with 17 animals in 1928 (Campbell and Hinkes 1983). Supernumerary teeth were not common in Bison before the species was hunted to near-extinction late in the last century; 185 of the museum specimens examined were of wild animals alive during the 1880's or earlier, and none had supernumerary teeth. Bison recovered largely through initiation of new herds, many of them founded with few animals and perhaps affected by inbreeding and genetic drift.

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Wolves, *Canis lupus*, Kill Female Black Bear, *Ursus americanus*, in Alberta

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Horejsi, Brian L., Garry E. Hornbeck, and R. Michael Raine. 1984. Wolves, *Canis lupus*, kill female Black Bear, *Ursus americanus*, in Alberta. Canadian Field-Naturalist 98(3): 368–369.

A pack of eight wolves (*Canis lupus*), killed a female Black Bear (*Ursus americanus*), apparently after driving her out of an exposed den. Two cubs survived the incident by climbing a tree.

Key Words: Wolf, *Canis lupus*, Black Bear, *Ursus americanus*, predation.

Rogers and Mech (1981) have reviewed the literature respecting bear and wolf interactions. They recount two recent instances of wolves (*Canis lupus*), killing Black Bears (*Ursus americanus*), one related to them by a second party and one they encountered during their own telemetry study. Recent literature does not contain any additional reports of wolves killing bears. This note, however, relates an incident we encountered in which wolves killed a female Black Bear.

On 19 December 1982 we were conducting a helicopter census of Moose (*Alces alces*), in the Wapiti River drainage of west central Alberta (Longitude 120° 17′ Latitude 54° 40′). At 1000 h we observed eight Gray Wolves in an alder (*Alnus* sp.) thicket. On the basis of size alone we classified the wolves as four adults and four young. There was evidence of a kill at the site, including three areas where the snow had been trampled, one of which had a red tinge from blood, and a small piece of hide on which three of the young wolves were tugging. We were immediately struck by the obvious difference in the appearance of this site as compared to that we had come to associate with Moose and American Elk (*Cervus canadensis*), kills. There was no head, no lower limbs, and neither rumen contents nor the stain they produce. After examining the site with binoculars we left.

At 1500 h we returned to the kill site intent on landing and examining it from the ground. Before landing we attempted to relocate the wolves and found only three at the original location. We broadened our area of search and observed, about 400 m from the kill site, two brown phase Black Bear cubs high in an aspen tree. The cubs were snow covered and were clasping each other, one on either side of the tree trunk which was about 13 cm in diameter at that point. At the base of the tree were three wolves and 15 m away there were two more wolves. They slowly moved away as we circled the area. We then landed and examined the kill site and surrounding area.

The bears had denned 20 m from the base of the aspen the two cubs were in. In retrospect, the sow had made a poor choice — the den was under the roots of a partially fallen clump of willow (*Salix* sp.), at ground level, and unprotected on two sides. Snow was only 15 cm deep, leaving the bears almost completely exposed.

Tracks in the snow indicated the following events. The cubs went directly to the tree they were in when we first saw them. It is not known whether they reached the aspen while the female fought the wolves off or whether they ran to it after she and the wolves had left the den site. In either case the wolves chased the female down slope through a thick stand of alder and willow before they killed her 400 m away. She died at the base of several large aspen trees in a shallow draw. There was no evidence that she had tried to climb a tree.

The kill site was covered with Black Bear fur. There we found one hind foot. Despite an extensive search of the immediate area we were able to recover only one forefoot and two pieces of bear hide, each 30 × 30 cm in size. There was no sign that any of the wolves had been injured.

There had been a very light snow fall the night of 18 December and most tracks at the site were covered with a very thin layer of snow. The snow on the cubs, and the absence or rigor mortis in the foot joints of the dead female, suggested the kill had taken place on the 18th.

On 20 December, at 1100 h, we again flew over the site. Both cubs were on the ground at the base of a large aspen only 10 m from the tree they had been in when first observed. The wolves were not seen in the area. Although both cubs appeared to be well their future was in doubt. We suggest their best chance for survival was in reoccupying the den their mother had selected.

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The Caryopsis as a Support Organ for Germinating Wild Rice, *Zizania aquatica*

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Bayly, I. L. 1983. The caryopsis as a support organ for germinating Wild Rice, *Zizania aquatica*. Canadian Field-Naturalist 98(3): 369–370.

In both field and laboratory studies of germinating Wild Rice (*Zizania aquatica*), the caryopsis has been observed to function as an anchorage appendage until the young roots are able to take over this function.

Key Words: Wild Rice, *Zizania aquatica*, caryopsis, germinating

The caryopsis of Wild Rice (*Zizania aquatica*) has several interesting adaptive features in terms of self-sowing. It is base-heavy, and possesses a long slender, persistent awn. The fruit, together with the awn and firm persistent lemma, is armed with strong, retrorse epidermal appendages. So adapted for effective self-seeding is the entire disseminule that on abscising from the inflorescence, it falls so that the heavy base embeds itself in the sedimentary substrate. The retrorse epidermal appendages further aid in the successful retention of the caryopsis in the substrate, effectively allowing it to move in only one direction, viz, deeper into the sediments.

In the summer of 1982 and the winter of 1982–1983, a study of nutrient utilization in wild rice was made at Mud Lake (Ardoch, Ontario) and in the aquatic growth room at Carleton University. Both in the field and on the various laboratory substrates, a special relationship between caryopsis and the young rice plant was observed. The caryopsis is positioned in the substrate so that it functions as a most effective anchor, without which the young plant would be unable to remain in the substrate (Figure 1). This behaviour is undescribed in any of the major literature dealing with wild rice (Chambliss 1940; Dore 1969; Fassett 1924; Thomas and Stewart 1969). The caryopsis "anchor" persists well into late June, when the root system is well able to sustain the plant and retain it in the substrate.

The importance of the caryopsis adaptation to the successful growth of wild rice seedlings is threefold.

Figure 1. The caryopsis, attached to the young seedling. Note angle of caryopsis in relation to main stem.

First, the caryopsis efficiently plants itself into the sediment, so that stands of wild rice are not moved from year to year by water currents. Second, the angled position of the persistent caryopsis retains the young seedling *in situ* while the roots are minimal and incapable of performing the function of anchorage. Third, the caryopsis effectively offsets the buoyancy of the submerged leaves. Without the caryopsis "anchor", the aerenchyma in the submersed leaves would cause the seedling to float to the surface and be lost as a part of the viable population. Thus the caryopsis not only functions as disseminule in Wild Rice, but also as a preliminary anchor for the growing seedling — an interesting dual role.

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More on "Peculiar Damage to Mature Spruce Trees"

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Jorgensen, Erik, and Anthony J. Erskine. 1984. More on "Peculiar damage to mature spruce trees". Canadian Field-Naturalist 98(3): 370-371.

Unusual damage to numbers of trees in a small area, earlier attributed to violent winds during a thunderstorm, is now thought to be caused by lightning, although very different from its typical effects.

Key Words: Spruce trees, *Picea glauca*, damage, lightning.

Erskine (1976) reported on unusual damage to mature spruce trees and advanced an hypothesis to explain it. In this note we report additional examples of the same phenomenon, with a different explanation.

In the summer of 1962 forestry personnel reported to Jorgensen "a strange new ailment on fair sized white spruce east of Longlac", near the highway crossing of Pagwa River, Ontario (letter from A. L. K. Switzer, Kimberly-Clark Ltd., Longlac). Investigations indicated that (1) only White Spruces (*Picea glauca*) were affected, although several other tree species were present in those stands; (2) a narrow strip of dead cambium extended upward from the damaged area, as is typical with lightning damage; (3) the damaged area appeared to extend from the root collar out on major roots above soil level as well as up the stem to a height of about 2 m; more than one damaged area occurred on some trees with the widest damaged area where major roots joined the stump; (4) the damage had occurred near the end of growth in 1958, as shown by sections taken from affected trees that were not killed by stripping of bark (W. R. Haddow, Ontario Department of Lands and Forests, Maple, Internal Report 1962). The descriptions and photographs from that event precisely paralleled those observed in 1970 by Erskine. An additional event of the same type was reported to Jorgensen in 1962, but not investigated, on the Steel River northeast of Terrace Bay, Ontario.

The damage seems to result from electric currents during lightning storms. As the current is conducted along sap canals, the sap is vaporized explosively, blowing the bark outward in strips. In a typical lightning strike, trees are entered by lightning within the crown, and the electrical current (charge) blasts a strip of wood and bark as it moves down toward the ground following the grain of the wood; however, no such "typical lightning damage" was seen in the stands investigated in 1962 and 1970. In the reported cases wood was not splintered but the bark was split from the wood. The current presumably follows the path of least resistance, both in the tree and in the soil. What we have seen is damage concentrated at the base of the tree, extending out onto the root bases as well as

FIGURE 1 (a & b). Damage to mature White Spruces near Pagwa River, Ontario (photographs by the late A. S. Mitchell).

upward along the trunk for 1–2 meters. Apparently this results from currents moving upward from ground level. This might happen in the course of an upward discharge from tree to cloud, but this explanation seems unlikely to cover the observed concurrent damage to a number of trees in a relatively small area. Lightning experts assure us that an individual lightning downstroke can damage only a single tree (G. F. Freier, University of Minnesota, personal communication). We were unable to learn whether individual lightning storms ever produce such concentrations of "strikes" as could account for the groups of damaged trees we have documented (frequencies averaging 5 trees/ha over an area of 15 ha).

A more plausible mode might include upward movement subsequent to an initial downstroke. The current reaching the ground may spread through the roots of trees if these conduct the current better than the soil. Such a current reaching the root systems of other trees through root grafts between trees may flow upward in these trees. This could explain why only spruces were affected, since root grafting is known only between trees of the same species. The event in 1958 was reported as having occurred near the end of growth, but explosive vaporization of sap might be expected to terminate growth for that year; the phenomenon may be tied to the major period of sap flow in spring or early summer, as was perhaps the case in June 1970. The scarcity of these events presumably reflects the rare combination of frequent lightning storms with soil and trees of suitable conducting character. All such events we have learned of to date were located within the Clay Belt of Ontario and Québec.

The damage caused by bears, which earlier was rejected as an explanation for the 1970 event, might perhaps occur as a sequel. Bears attracted to sap exposed in the pattern described might go on to strip off more bark, completely girdling a tree, and then assault other nearby trees, as described by W. D. Zeedyk (1957) in Maine.

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New or Additional Moss Records from Nova Scotia and Québec

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Belland, René J. 1984. New or additional moss records from Nova Scotia and Québec. Canadian Field-Naturalist 98(3): 372–374.

Seven mosses, *Entodon concinnus, Pohlia filiformis, Seligeria diversifolia, S. donniana, S. recurvata, S. tristichoides*, and *Timmia norvegica* var. *excurrens*, are reported new to Nova Scotia while five, *Brachythecium collinum, Grimmia incurva, Pseudoleskea patens, Schistidium trichodon* and *Seligeria donniana*, are new to Québec. Distributional notes are provided for five additional moss species that are rare in southeastern Canada, or are major range extensions to this region.

Key Words: mosses, Québec, Nova Scotia, phytogeography, distribution

This paper reports on new or additional moss records from Nova Scotia and Québec. The records result mainly from field work during 1982 in the Cape Breton Highlands (Nova Scotia) and Gaspé Peninsula (Québec).

All collection numbers are the author's, except where otherwise indicated. Voucher specimens are deposited in the Bryophyte Herbarium at Memorial University of Newfoundland (NFLD).

Arctoa fulvella (Dicks.) B.S.G.

Québec: Tabletop Mountain, 1065-1110 m, 2-7 August 1906, *Collins 4308, 4435* (FH-Bartram) (verified by Guy R. Brassard); Comté de Matane, Chic-Choc Mountains, north-facing cirque on Mont Logan, 49° 53′N, 66° 37′W, *5266, 5270*.

These citations document the occurrences of *Arctoa fulvella* from Québec. Ireland, Birch, Schofield, and Vitt (1980), and Crum and Anderson (1981) reported the species from "Québec", and Brassard (1983) mapped one locality in Gaspé. No specimens were cited in any of those reports.

Arctoa fulvella is an alpine moss (Mårtensson 1956) which is disjunctive in North America between the Western Cordillera and the Northern Appalachians (Crum and Anderson 1981). The species was mapped for North America most recently by Brassard (1983).

Brachythecium collinum
(Schleich. *ex* C. Muell.) B.S.G.

Québec: Comté de Gaspé-Est, Percé area, Pic de l'Aurore, ca. 48° 31° N, 64° 14′W, *5091, 5092*; Comté de Gaspé-Est, Percé area, "l'Ampithéâtre", ca. 48° 31′N, 64° 14′W, *5097, 5105*; Comté de Gaspé-Est, Forillon Peninsula, Mont St-Alban, 48° 48′N, 64° 13′W, *5153*.

New to eastern North America. *Brachythecium collinum* is disjunctive from western North America. Lawton (1971) cites its distribution there as ". . . all states and provinces of the Pacific Northwest . . .; Saskatchewan, North Dakota".

Cyrtomnium hymenophylloides (Hüb.) Kop.

Nova Scotia: Inverness County, Cape Breton Highlands National Park, Corney Brook gorge, 46° 43′N, 60° 52′W, *4852*; Inverness County, Cape Breton Highlands National Park, near mouth of Big Southwest Brook, 46° 45′N, 60° 41′W, *4933*; Pictou County, Drysdale Falls, *Brassard 12390*.

Cyrtomnium hymenophylloides is a rare arctic-alpine species in the Maritimes where it has been reported only twice previously, from New Brunswick (Ireland 1982).

At Big Southwest Brook, *Cyrtomnium hymenophylloides* was found with two other arctic-alpine mosses, *Plagiobryum zierii* (Hedw.) Lindb., and *Timmia norvegica* var. *excurrens* Bryhn. All three taxa are generally considered calcicolous. In studies of calcicolous arctic-alpine vascular plants at this site, Hounsell and Smith (1968) reported the pH of soil samples as acidic (pH 3.8 and 5.5), and with low amounts of exchangeable calcium and magnesium. They attributed the survival of the arctic-alpine vascular plants at Big Southwest to a combination of physical factors other than pH, including shade, moisture, low temperature, exposure, and instability of habitat (cliffs and talus). It is possible that some of these factors, particularly low temperature and moisture, may account for the existence of the arctic-alpine bryophytes at Big Southwest.

Entodon concinnus (De Not.) Par.

Nova Scotia: Inverness County, Cape Breton Highlands National Park, Corney Brook gorge, 46° 43′N, 60° 52′W, *4859, 4875*.

New to the Maritimes. In eastern North America, *Entodon concinnus* has a disjunct distribution, where it is also known from Newfoundland (see map in Belland and Brassard 1981), North Carolina and Tennessee (Crum and Anderson 1981). Steere (1978) has mapped its North American distribution, and Belland (1981) has discussed the phytogeography of the species in Newfoundland.

Grimmia incurva Schwaegr.

Québec: Comté de Matane, Chic-Choc Mountains, north-facing cirque on Mont Logan, 49° 53′N, 66° 37′W, *5271, 5313*; Comté de Gaspé-Ouest, Lac aux Américains area, barrens and cliffs above north side of lake, 48° 58′N, 66° 01′W, *5396*; Comté de Gaspé-Ouest, Mont Jacques-Cartier area, 48° 59′N, 65° 56′W, *5552*.

The only previous report of this species from eastern North America (excluding Greenland) is in Newfoundland (Hedderson et al. 1982). *Grimmia incurva* is a mountain moss which is disjunctive from western North America where its range is "...Oregon; Colorado, South Dakota" (Lawton 1971).

Myurella tenerrima (Brid.) Kindb.

Québec: Comté de Matane, Chic-Choc Mountains, north-facing cirque on Mont Logan, 49° 53′N, 66° 37′W, *5295*.

This is the first record of this arctic-alpine moss in southeastern Canada, and represents a major range extension from the north and west. The nearest stations are from the Schefferville area, Québec (Crum and Kallio 1966; Ireland, Bellolio-Trucco and Kallio 1980), central Labrador (Brassard and Weber 1978), and Ouimet Canyon and Canyon Lake Canyon, Ontario (Ireland and Bellolio-Trucco 1979).

Orthothecium chryseum
(Schwaegr. *ex* Schultes) B.S.G.

Québec: Comté de Gaspé-Ouest, Chic-Choc Mountains, granite cliffs above Lac aux Américains, 48° 57′N, 66° 00′W, *5447, 5454*.

This is yet another arctic-alpine moss with a major range extension to southeastern Canada. The nearest published reports are from northern Québec (Ireland et al. 1980a) and Labrador (Brassard and Weber 1978).

The habitat of *Orthothecium chryseum* at Lac aux Américains is a small, exposed, N-facing granite "quarry" at about 960 m. Scoggan (1950) has erroneously reported the nature of the bedrock in this area as "... calcareous" (p. 3) and "... limestone" (p. 373, plate IIB). I was unable to locate any limestone outcroppings at Lac aux Américains despite extensive searches. *O. chryseum* is calcicolous, but was growing over granite bedrock in seepage which had a pH of 4.8-5.1. Several other calcicolous bryophytes were found at or near the *O. chryseum* site (e.g., *Ditrichum flexicaule* (Schwaegr.) Hampe, and *Plagiopus oederiana* (Sw.) Limpr.) as well as several calcicolous arctic-alpine vascular plants (e.g., *Anemone parviflora* Michaux, and *Saxifraga aizoon* Jacq. var. *neogaea* Butters). As with *Cyrtomnium hymenophylloides*, physical factors other than pH may allow the persistence of the plants in this habitat.

Plagiobryum zierii (Hedw.) Lindb.

Nova Scotia: Inverness County, Cape Breton Highlands National Park, Corney Brook gorge, 46° 43′N, 60° 52′W, *4856, 4870*.

This is only the second station for this arctic-alpine moss in Nova Scotia. It was previously collected from nearby Big Southwest Brook (Ireland 1982).

Pohlia filiformis (Dicks.) Andr.

Nova Scotia: Inverness County, Cape Breton Highlands National Park, south branch of Corney Brook, 46° 42′N, 60° 54′W, *4909*.

Reported only once previously in the Maritimes from New Brunswick (Ireland 1982). In eastern Canada *Pohlia filiformis* is also known from Ontario, Québec, Newfoundland and Labrador (Ireland, Bird, Schofield and Vitt 1980).

Pseudoleskea patens (Lindb.) Kindb.

Québec: Comté de Matane, Chic-Choc Mountains, north-facing cirque on Mont Logan, 49° 53′N, 66° 37′W, *5268*.

In eastern North America, *Pseudoleskea patens* is known also from Michigan, Ontario, New Hampshire, Nova Scotia, and Newfoundland (Crum and Anderson 1981). According to Crum and Anderson (1981), and Lawton (1971), *P. patens* grows mainly in alpine habitats.

Schistidium trichodon (Brid.) Poelt

Québec: Comté de Bonaventure, Ruisseau Allard, "Les Falls", 48° 12′N, 66° 22′W, *4987*.

The only previous reports of this rare moss in eastern North America are from Newfoundland (Hedderson et al. 1982). The species is rare and widely disjunct in North America. The North American locality nearest to the Gulf of St. Lawrence stations is in coastal Alaska (Bremer 1980). According to Bremer, *Schistidium trichodon* is restricted to mountain areas.

Seligeria diversifolia Lindb.

Nova Scotia: Victoria County, near MacLeods Pool on North River, 49° 19′N, 60° 40′W, *4769*.

Seligeria diversifolia is rare in the Maritimes, where the only other known station is northern New Brunswick (Ireland 1982).

Seligeria donniana (Sm.) C. Muell.

Nova Scotia: Victoria County, Cape Breton Highlands National Park, Little Southwest Brook, 46° 48′N, 60° 38′W, *4808*; Inverness County, Cape Breton Highlands National Park, MacIntosh Brook, 46° 48′N, 60° 46′W, *4810*.

Québec: Comté de Bonaventure, Ruisseau Allard Est, 48° 10′N, 66° 22′W, *4985*; Comté de Gaspé-Est, Percé area, "La Grotte", ca. 48° 31′N, 64° 14′W, *5059*.

New to the Maritimes and Québec. *Seligeria donniana* has a wide distribution in eastern North America (see map in Vitt 1976) and its occurrence in Québec and the Maritimes was to be expected.

Seligeria recurvata (Hedw.) B.S.G.

Nova Scotia: Pictou County, Welsford area, along River John near Welsford, *4962*.

Seligeria recurvata is rare in the Maritimes, where it has been reported from a single locality in New Brunswick (Ireland 1982). Vitt (1976) regards *S. recurvata* in North America as "rare and sporadic".

Seligeria tristichoides Kindb.

Nova Scotia: Victoria County, Cape Breton Highlands National Park, Little Southwest Brook, 46°48′N, 60°38′W, *4809*.

New to the Maritimes. In eastern North America, the species occurs from Newfoundland and Gaspé Peninsula southward to northern Vermont (Vitt 1976).

Timmia norvegica Zett. var. *excurrens* Bryhn

Nova Scotia: Inverness County, Cape Breton Highlands National Park, near the mouth of Big Southwest Brook, 46°45′N, 60°41′W, *4918*.

This is the first report of the species *Timmia norvegica* from the Maritimes. However, both var. *norvegica* and var. *excurrens* have been reported from Newfoundland (Tuomikoski et al. 1973; Brassard 1979; Belland and Brassard 1981). Brassard (1979) has mapped the world distribution of var. *excurrens*.

Acknowledgments

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Polystichum lemmonii, a Rock Shield-fern New to British Columbia and Canada

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Cody, William J., and Donald M. Britton. 1984. *Polystichum lemmonii*, a Rock Shield-fern new to British Columbia and Canada. Canadian Field-Naturalist 98(3): 375.

Polystichum lemmonii is reported as new to the flora of British Columbia and Canada. Its peculiar affinity to serpentine rocks is pointed out, its overall range is given, and the plant is described briefly.

Key Words: *Polystichum lemmonii*, Rock Shield-fern, British Columbia, Canada

Kruckeberg (1964) pointed out the highly predictable occurrence on and restriction to ultramafic soils of two fern species in the Pacific Northwest, *Polystichum mohrioides* (Bory) C. Presl var. *lemmonii* (Underw.) Fern. (Rock Shield-fern) and *Cheilanthes siliquosa* (Indian's Dream), and stated that *Adiantum pedatum* var. *aleuticum* (Northern Maidenhair), showed a strong preference for the same substrates. Again Kruckeberg (1969) made detailed studies of plant life, including the above mentioned ferns, on serpentinite and other ferromagnesian rocks in northwestern North America.

Because of the affinity of *Polystichum lemmonii* Underw. to serpentine rock formations, it was not surprising that this species was found on such rocks in the Okanagan Divide in southern interior British Columbia. The plant is both new to the flora of British Columbia and Canada. Data are as follows: BRITISH COLUMBIA: 6000 ft., westward of Westbridge, Okanagan Divide, *F. Tusko & W. Arlidge*, 26 July 1961 (DAO).

More exact locality data have kindly been provided by J. W. C. Arlidge, Victoria, B. C. (personal communication): West Kettle Valley Area, 18 km west of Westbridge, 49°11′N, 119°13.5′W. Okanagan Highland, mountain ridge 3 km northeast of Baldy Mt., at head of Rock Creek, 6000 ft. a.s.l., close to timberline.

Polystichum lemmonii is now known to occur from the Okanagan Divide in southern British Columbia, south through the northern Cascades in Washington to Placer County, California, and is apparently isolated in the southern Blue Mountains of eastern Oregon (Wagner 1979). A map of the previously known distribution is given by Wagner (1979). The species is found in crevices of rock outcrops and cavities under boulders of talus slopes in subalpine or occasionally midmontane sites.

Polystichum lemmonii can be recognized by the densely clustered, 15 to 35 cm long, linear to lance-oblong fronds; the crowded pinnae are deeply pinnatifid, or the lower pinnate, the ultimate segments oval, obtuse, crenate or crenately lobed and not at all spinulose; the sori are situated towards the base of the pinnules of the middle and upper pinnae, and the indusia, which are large and tend to overlap, are entire or but obscurely erose-toothed.

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News and Comment

Notice of The Ottawa Field-Naturalists' Club Annual Business Meeting

The 106th Annual Business Meeting of the Ottawa Field-Naturalists' Club will be held in the auditorium of the Victoria Memorial Museum Building, Metcalfe and MacLeod Streets, Ottawa on Tuesday, 8 January 1984.

BARBARA MARTIN
Recording Secretary

Project Information Requested: Directory of Co-operative Naturalists' Projects in Ontario

The 1985 edition of the *Directory of Co-operative Naturalists' Projects in Ontario* will soon be compiled. The Directory is designed to publicize projects that rely on volunteer help and to attract wider participation in them. Selected project descriptions are published in *Seasons*, the magazine of the Federation of Ontario Naturalists, in addition to their inclusion in the directory.

Examples of projects in the 1984 directory include Christmas Bird Counts, inventories of natural areas, and county plant and bird checklists. Most projects to date have been bird studies, but a substantial number on other subjects have been included, and we are particularly interested in including more non-bird projects.

Naturalists interested in undertaking a project which may benefit from inclusion in the directory are invited to write the compilers for a project description form, at the following address: Clive and Joy Goodwin, Directory of Co-operative Naturalists' Projects in Ontario, 45 Larose Ave., Apt. 103, Weston, Ontario M9P 1A8.

MARTIN K. MCNICHOLL

Long Point Bird Observatory, P.O. Box 160, Port Rowan, Ontario N0E 1M0

Request for Information: Color-marked Common Terns

The Canadian Wildlife Service, Ontario Region, is continuing its program of color-marking Common Terns at two colonies in the lower Great Lakes to determine their post-breeding dispersal, migration routes and winter range.

In 1981 adults were marked with orange wing-tags and chicks with pink tags. Tags were put on both wings of all birds. All tags had combinations of letters and numbers (the two tags on any bird each had the same combination). In addition, all birds received a metal legband on one leg and a plastic legband (yellow with a black horizontal stripe) on the other leg.

In 1982 many of the adult tagged birds returned to their colonies still carrying their tags. The tagged birds appeared fit and nested normally. Most tags were still clearly legible and showed little wear. In 1982 bright blue wing tags (with black lettering) were put on adult Common Terns and black tags (with yellow lettering) on chicks just prior to fledging.

In 1983 many terns tagged in 1981 and 1982 were back at their colonies. In that year red wing tags (with yellow lettering) were put on adult Common Terns and green tags (with yellow lettering) on chicks.

In 1984 several terns tagged as adults in previouys years were back at the nesting colonies. In addition, a few immatures tagged in 1981 returned to nest as adults. In 1984 white tags (with a red trim and red lettering) were put on adult Common Terns and yellow tags (with black lettering) on chicks.

When you observe a tagged tern would you please report the date, location, color of the tag, and, if possible, the number/letter combination to: Banding Office, Canadian Wildlife Service, Headquarters, Ottawa, Ontario, Canada K1A 0E7. All reports will be acknowledged.

HANS BLOKPOEL
Canadian Wildlife Service, Ottawa K1A 0E7

Raptor Research Foundation Conference — November 1985 — Announcement and First Call for Papers

The 1985 Raptor Research Foundation (RRF) International Meeting and Symposium on the Management of Birds of Prey will be held at the Capitol Plaza Holiday Inn in Sacramento, California 2-20 November 1985. Highlights of the meeting will include 1) the Second RRF Conference on Raptor Conservation Techniques — Twelve Years of Progress, 1973-1985; 2) a Western Hemisphere Meeting of the World Working Group on Birds of Prey (ICBP); 3) the Second International Vulture Symposium; 4) a Western North America Osprey Symposium; 5) a Workshop on North American Candidate Endangered Raptors; 6) an International Symposium on Raptor Reintroduction; and 7) a Symposium on Raptor Rehabilitation, Captive Breeding, and Public Education. For more information or if you are interested in presenting a paper, please contact Dr. Richard R. Olendorff, U.S. Bureau of Land Management, 2800 Cottage Way, Sacramento, California 95825, or Nancy Venizelos, San Francisco Zoological Society, Sloat Blvd. at the Pacific Ocean, San Francisco, California 94132.

NANCY VENIZELOS

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Appeal for the St-Lawrence Belugas

Formed in June 1984, the "Fondation Béluga" has one single objective: to promote the survival of the Beluga or white whale, *Delphinapterus leucas*, population of the St-Lawrence estuary.

The Beluga is found in several arctic and subarctic localities of America and Eurasia, but the St-Lawrence resident population is the southernmost stand of the species. It is a remnant of a much more extensive population inhabiting the truly arctic waters of the former Champlain sea of the last glacial age. To this day, cold fertile upwellings support a rich plankton and fish production along the north shore of the lower estuary. Until the late 19th century, there were reports of thousands of animals along hundreds of miles of coast, at least from Ile-aux-Coudres down to Anticosti. The population is now mostly restricted to a stretch of about 80 km centered around the mouth of the Saguenay river.

These gregarious and inquisitive marine mammals were heavily hunted for a long period, from the arrival of the first Europeans until 1955. They are now protected through legislation dating from 1979. Although hunting was much reduced after 1955, and protective measures have been taken for the last 15 years, there are no definite indications that the population is recovering. Two successive estimates of recent population numbers both indicated a "stable" average around 500 animals, but with an error margin of some 200.

In addition to carrying these censuses, the Federal Department of Fisheries and Oceans has sponsored a study of stranded animals reported along the shores of the St-Lawrence. Results show that causes of mortality are varied, and that total mortality is difficult to estimate, with an unknown number of deaths going unreported. This suggests that the population could still be declining, to a figure lower than the generally accepted 500 white whales. Autopsies have revealed a plethora of diseases and pathological conditions in animals of all ages. Chemical analyses on a number of tissues have shown high levels of pollutants. In most cases, organochlorine (PCB, DDT) loads are higher than levels known to impair reproductive function in domestic animals. Moreover, immunosuppression is a well-known effect of these compounds and could render Belugas more susceptible to parasitic infestation and infections by opportunistic microorganisms. Both these conditions were diagnosed in some stranded animals. However, a direct link between organochlorine induced immunosuppression and the observed conditions is difficult, if not impossible, to establish without experimental work.

The heart of the Beluga population is at the head of the Laurentian channel where oceanic waters running deep from the Atlantic Ocean meet those from two large rivers. Each water mass contributes its load of nutrients, living organisms and floating debris. They are then braided together in a complex fashion by the physics of tides and weather. This realm of deep trenches and estuarine shoals is ideal at all seasons for the maintenance of carnivorous Belugas with a diverse diet. But the waters, prey and sediments also hold an array of pollutants originating in the industrial center of North America and deposited at this crossroad for shipping to the major St-Larence basin ports.

With its shoals, rocky cays and islands, its frequent fog banks, its fast-changing and strong currents, the region traditionally presented formidable dangers to ships. This may account in part for its remaining a stronghold of the Beluga population. In this century,

increasing traffic has turned ships into hazards for the Belugas who are wary of their fast hulls and noisy propellars. In the last few years, tourist enthusiasm for all kinds of whales (blues, fins, minkes and humpbacks) that visit the area, has put additional pressure on the Belugas. It is possible that the number of crafts covering the area, albeit for innocent purposes, may have already reached a critical level. The remaining Belugas may find themselves too often driven away from preferred areas for the pursuit of their traditional activities.

The "Fondation Béluga" was formed by a small group of scientists and concerned biologists involved in research on the Beluga or in the promotion of natural sciences. It wishes to establish a position that is independent, although not necessarily opposed, to that of government or other agencies involved in the management or tourist-oriented aspects of the species. The foundation is determined to obtain independent estimates of population numbers, to evaluate reproductive success and, if necessary, to seek the establishment of a natural reserve including their prime habitat.

In the first phase of funding, an appeal is made to the general public in the form of poster selling for a minimum tax-deductible $5. It depicts Belugas welcoming tall ships to the Jacques Cartier celebrations, with a greeting of "450 years without complaining" (in French). Send donations to the "Fondation Béluga", PO Box 147, Rimouski, Québec G5L 7B7.

PIERRE BÉLAND
DANIEL MARTINEAU

Editor's Note: The St. Lawrence River Beluga population was classified as "endangered" by The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in April 1983 (*see* Cook and Muir. 1984. Canadian Field-Naturalist 98(1): 69, Table 2; and Campbell, 1984, Canadian Field-Naturalist 98(1): 72, Table 1. An edited version of the Status Report accepted by COSEWIC on which this decision was based will appear in a future issue of *The Canadian Field-Naturalist*.

FRANCIS R. COOK

A Tribute to Charles Henry Douglas Clarke, 1909–1981

Harry G. Lumsden

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On 25 March 1981 Dr. C.H. Doug Clarke went ice fishing on Lake Simcoe. After a period in the same place the ice gave way under him. Some nearby fishermen came to help and a young man, Randy Bush, also fell through the ice. Both were drowned in this freak accident. Thus ended a distinguished career as a wildlife research scientist, administrator, writer and philosopher.

Doug was born on 14 June 1909 at Kerwood, Ontario, where his father was a Methodist minister. His mother was a teacher with a talent and love for mathematics. She was also a naturalist — a competent botanist who knew her birds. Doug recorded that when he was about five, his mother suggested a bird nesting picnic with some interested neighbours. He later wrote about the excitement of the day and his first view of nests of Catbird, Brown Thrasher, and Yellow Warbler.

It was the custom in those days for a Methodist minister to move to a new church every four years. Doug therefore moved with his family to Harrow in 1912, to Sarnia in 1916, to Brussels in 1920, and finally to Goderich in 1924. Today we would be concerned about frequent moves and disruption of friendships having a detrimental effect on a child. There seems to be little evidence that Doug was bothered by this. He did not talk about childhood friends and left no record of regret at terminated friendships. He wrote that no friends accompanied him on his naturalist forays or when later he went hunting. He was very much a loner.

In Sarnia, where he first went to school, he met a French Canadian doctor who was a first-class naturalist and a leader in the community. He was a keen Woodcock hunter with good dogs and fine guns and, although Doug was too young to accompany him, he impressed Doug with the idea that Woodcock hunting was the ultimate in sport.

At an early age, on an uncle's farm, where there was a rich archaeological site, Doug was introduced to "Indian relics". In later life this developed into a genuine interest in archaeology. He was a charter member of the Ontario Archaeological Society and carried out two highly professional excavations of early logging sites in Algonquin Park. These excavations were carried out during summer vacations and the products were used for exhibits in the Museum in Algonquin Park.

There were others who influenced Doug's early interests, and to whom he gave credit for doing so in later life. Before the first world war he attended a lecture by W. E. Saunders who talked using a tray of stuffed birds to illustrate points. Hoyes Lloyd, Superintendent of Wildlife Protection for Canada, visited a youth camp on Beausoleil Island near Honey Harbour at which Doug spent part of a summer. He taught Doug how to make bird study skins.

There were other formative experiences. Borrowed from libraries were books by missionaries and travellers. He later wrote that these were valued according to the amount of wildlife in them. "When missionaries dwelt on the workings of the Holy Spirit, I could take in a page a second, but when the Indians and their hunting were described, and ducks began to quack and jackfish to thrash in the net, I dwelt lovingly." In particular he read Livingstone and his father-in-law Moffat's accounts of wildlife in Africa, and Teddy Roosevelt's hunting experiences. He acquired for 50 cents Taverner's *Birds of Eastern Canada,* a book that he wrote "can never be sufficiently praised." It turned him from a naturalist into an ornithologist.

Later he was given a pair of X4 power opera glasses for Christmas, which opened up a new world for him.

His first gun was a borrowed Zulu-war Snider converted to shot, but he killed his first game with the family "rabbit-eared" twelve gauge when, shortly after the age of 11, the family moved to Brussels.

All his life he enjoyed collecting wild foods. His introduction to this came as a child in family expeditions to catch chub and suckers during the run. He recorded what fun it was to participate in tapping maples for syrup, collecting leeks and morels in spring, and wild strawberries in summer, or mushrooms, puffballs, elderberries and crabapples in fall, and high-bush cranberries after they had been touched by frost.

When the family lived at Harrow they acquired a lot and built a cottage on the shore of Lake Erie, west of Kingsville. Here he caught his first sunfish to be speedily followed by catfish, sheepshead, bass, and other species. Only later when the family had moved to Brussels did he catch his first trout. This was on his birthday and he later wrote that he did not think another memorable thing happened to him on a birthday until many years later when, in Africa, he saw his first wild lion. He seldom fished for the larger, more spectacular game species, but chose to go for speckled trout, smelts, perch, catfish, and herring.

Experiences in his childhood, a lively imagination,

and perhaps something basic in his nature led him to ". . . want passionately to lead a life that would take me to strange and interesting places where I would see new things. Therefore much against the wishes of my teachers and my father, I rejected the conventional law-politics-economy-teaching-syndrome, and sought for university training that would fit my wishes." Training in forestry was not Doug's first choice but there were virtually no jobs in biology at that time. He later wrote that forestry undergraduates were virtually guaranteed summer jobs in the bush and that this somewhat tempered his lack of enthusiasm. His summer jobs in the bush first took him to the Goulais River — Ranger Lake area north of Sault Ste Marie on a regeneration survey. The next year he worked in northern Manitoba in the Cormorant Lake ranger district cruising timber and, as ever, recording the birds he saw. 1929 was a bad year for fires and many of the lines the crew ran were through active fires. Field crews in those days virtually lived on game, and that summer, he recorded, they ate Moose, Mule deer, ducks, geese, and Sharp-tailed Grouse.

In the summer of 1930 he went even further afield, to the Rockies, to cruise timber and fight forest fires.

Doug had not intended to continue at the university to get a Ph.D., but Professor White made the necessary arrangements for him to move into the Zoology Department as a graduate student, without telling him. A train for home, accidentally missed, brought Doug by chance to Toronto on the last day for registration, and Professor Dymond hustled him through the formalities and made room for him and Duncan MacLulich in his university office. They shared field camps, MacLulich working on Snowshoe Hares and Doug on Ruffed Grouse. Because there was no money for out-of-pocket expenses, they used the Ontario Fisheries Research Laboratory at Franks Bay on Lake Nipissing, an old hunt camp at Buckshot Lake and a cabin in Biggar Township in Algonquin Park. As ever, his naturalist interests were indulged and he published a paper on the birds of Lake Nipissing.

In 1934 he was broke, but Frank McDougall, Superintendent of Algonquin Park (later Deputy Minister of the Department of Lands and Forests) hired him as a ranger and freed him to continue his work on Ruffed Grouse for most of the summer at Brûlé Lake in the Park.

His Ph.D. finished and thesis accepted, he worked for a few months as an instructor in Zoology and as a researcher in the Department of Bacteriology and Immunology, but he never wanted the academic university life.

In 1935, Dr. R. M. Anderson, Curator of Mammals at the National Museum in Ottawa hired Doug and sent him, with J. P. Stovell, to the Batchawana area on the shores of Lake Superior to collect mammals and birds.

In 1936 came his first big break in the north. The Northwest Territories Bureau asked the National Museum to help in a study of Muskoxen in the Thelon Game Sanctuary and R. M. Anderson chose Doug for the job. His assistant guide and friend was Billy Hoare, an ex-missionary and experienced arctic traveller. He had been a special caribou investigator appointed on the recommendations of the Reindeer and Muskox Royal Commission and was well qualified to help Doug on the Thelon investigation.

The first field season must have been frustrating because they saw Muskoxen only from the air, none while on the ground. The second summer they were able to fly to Huess Lake at the headwaters of the Hanbury River and thereby extended their time spent in the field. Doug, as usual, noted everything he saw, and collected as much as could be carried ranging from a skeleton of a Copper Indian to small fish. His report, a classic of its kind, deals with mammals, birds and fish, with long sections on Muskoxen and Caribou.

The Thelon study completed, Doug remained in Ottawa where he held a post in the Parks Wildlife Section and also administered the licensing system for the Northwest Territories.

In 1938, Doug married Muriel Langstroth whom he met when they were both doing post-graduate work at the university.

Investigational trips to Waterton, Banff and Jasper Parks followed. A controversy raged at the time about protection of Cougars in the Parks. The Alberta Game and Fish Association compaigned for years to have Cougars exterminated in parts, and Doug's job was to determine the facts. The real problem was overbrowsing by too many ungulates and the solution was to protect predators and cull the Elk herds. Against violent opposition, the Parks Branch did both.

Later trips took Doug to all the National Parks then existing in Canada, and back to the Arctic, this time down the Mackenzie and along the coast on the Mission boat the "Lady of Lourdes".

When the war broke out his occupation was reserved and he was unable to join the forces. This created a problem which Hoyes Lloyd helped him overcome when he later wanted to leave the Federal service.

In 1943, Doug provided the wildlife data for the North Pacific Planning Project, which was concerned with the war effort and the building of the Alaska Highway. As usual, he missed little that was to be seen and left notes on the Indian history of the area, archaeological sites, and descriptions of Dawson and

Charles Henry Douglas Clarke. Forestry Graduation photograph, spring 1931.

C. H. D. Clarke, passport photograph, taken in July 1972 before his last trip to Africa.

the Yukon changed and unchanged by the new developments.

In Ottawa that winter Doug found that the Director wanted him to take over the job of supervising the reindeer station near Aklavik and in addition, undertake biological surveys. This could have been attractive if adequate provision had been made for outside travel and salary adjustment. These concessions the Director refused to make, and Doug started negotiations to move from the Department of Mines and Resources in Ottawa to the Department of Lands and Forests in Ontario. He spent his last summer with the Federal Government on field work with Terry Shortt of the Royal Ontario Museum on the Alaska highway and he enjoyed it.

Doug's first job with the Department of Lands and Forests was to establish a wildlife research station in Algonquin Park. The first year a tent camp was built at the Lake of Two Rivers, but the next year a permanent station was established at Sasajewan Lake.

Doug was a leader, but his methods were different from those of others. If some member of a party was not pulling his weight on some chore, Doug would move in to help and, without a word of censure, he would work twice as hard and shame the slacker into greater efforts. Sometimes he led without consciously setting out to do so. I sometimes wondered why it was that those who worked closely with him were inspired to more than ordinary efforts. It was not until years later that I encountered a book called *The Exceptional Executive* by H. Levinson, that I thought I had found a clue. Levinson points out that the exceptional executive must be a leader and to lead he must be a teacher. It follows of course that to be a teacher, the leader must know his stuff. Knowledge was an attribute that Doug had in super abundance and he loved to share it.

Those who knew him in his last 20 years, might be surprised to know that Doug was basically a very shy man. Early in his career during his delivery of a paper at a meeting, he was nervous and not easy to listen to, but he conquered this and could speak very well as he grew older.

In 1946, the Department of Game and Fisheries was amalgamated with the Department of Lands and Forests, and became the Division of Fish and Wildlife with Dr. W. J. K. Harkness as the new chief. Doug left the Research Division and became assistant chief.

In the late 1940's and early 1950's wildlife management in Ontario became a technical activity at a time when few techniques were available and little was known about many of the important wildlife species of the province. Many of us who started our careers at that time, were sent into the field with instructions to look at the wildlife resources of our district, decide what were the most important problems which needed attention, and go ahead and work. Occasionally some complained about "lack of direction from head office" (who complains that way today?). I suppose that some preferred a more structured environment. It seemed to me that these were years of achievement for the province. Many had a hand in these developments, but Doug was always in the background to a greater or lesser degree, with advice, sound judgement, encouragement and humour. Sometimes he stepped out in front and gave firm direction.

Many new programmes were initiated in wildlife under Doug's leadership. Fur bearing animals were in decline under a system of competitive trapping. With Hugh Conn of the Federal Indian Affairs Branch and Jack Grew who joined Lands and Forests, a registered trap line system was established under Doug's leadership. A quota system for Beaver harvest was effective in doubling and doubling again the Beaver population. Marten, which survived virtually only in parks and Crown Game Preserves were live-trapped and moved and again became a commercial species in the province. Liberalization of regulations was pushed vigorously and seasons were opened on Hungarian Partridge and Bobwhite.

Doug's belief was that, to manage game well the

Banquet held at the National Arts Centre at the International Committee of Natural History Museums of the International Council of Museums (ICOM) meetings in Ottawa, June 1976. Doug Clarke (standing) was guest speaker and discussed his dealings with museums and what he saw their future to be. On Doug's left (the viewer's right) is Luis Monreal, Secretary General of ICOM, Paris, France. On Doug's right, Louis Lemieux, then Director of the National Museum of Natural Sciences, National Museums of Canada (the host of these meetings) and Chairman of the Committee, and on his right the USSR delegate Boris Saveliev.

wildlife biologist should be able to do all the things that sportsmen need to do, only better. He encouraged the field staff to hunt and once wrote a memo to the Minister to justify this stand. He pointed out that the Wildlife Branch had reason to regret having taken the advice of field men who never hunted.

Doug never lost his love of hunting. His first dog was a Labrador by the name of "Soot". She was well trained with a good nose and performed feats seldom equalled by other dogs. He estimated she had retrieved over 1000 head of game in her life. After the pheasant shoot on Pelee Island one year, it was necessary to make an estimate of the number of cripples left by hunters. In a single day "Soot" found and retrieved over 100 pheasants.

Doug obtained a Plott hound with which he hunted deer, raccoons, and foxes. Later he imported from Sweden the first Drever (hound) to reach North America. "Flash" was used to hunt deer, European Hares, and foxes. Later still he acquired an English Setter "Chick" with which he hunted Woodcock, Hungarian Partridges, pheasants, and Ruffed Grouse.

Doug had a deep sense of history, particularly of the Indians and Eskimos of Canada. He had admiration for their skills, sympathy for their outlook, indignation at their mistreatment, and interest in their welfare. For some years the policy on Indian hunting and trapping which he advocated and which was adopted, was to abide by the letter and spirit of the Indian treaties unless some vital principal of conservation arose. The need to reduce the subsistence kill by Indians of Woodland Caribou in northern Ontario was done, not by legislation and enforcement, but by exploiting, by reason and persuasion, the enlightened self-interest of the treaty Indians.

Some of us who worked at Maple, 20 miles from the main office, would go down to discuss some aspect of

the business of the Wildlife Branch. This would be given brief and sometimes perfunctory treatment, generally enough to indicate the direction in which he thought we should be going. What he really wanted to talk about was some new Indian artifact he had found, or Iroquois pottery. Sometimes it was big game in Africa, this was well before he went there, or perhaps it was an article he had read in Wildt und Hund or Svensk Jagt. These sessions were always interesting and informative. He had an astonishing memory and seemed to retain everything he had ever read.

In 1965, Doug went to Kenya for six months on a CIDA contract as an advisor to the Parks Department and perhaps typically beforehand, he buckled down to learn Swahili to make himself more effective.

In 1970, Doug suffered a heart attack and was hospitalized. He recovered and returned to an active and vigorous life.

Doug had been to Africa twice before for short visits and finally spent two years (1972-1974) in Tanzania as a special advisor to the Minister on wildlife and parks matters. He found life in Africa intensely interesting and made the most of his opportunities to see the wildlife and was also able to do some hunting. He made well-reasoned recommendations on land use and on the need to cull herds of ungulates, but was frustrated and disappointed in the lack of action on the part of managers and the fact that poaching seemed to be officially condoned.

Doug retired early from the Ministry of Natural Resources in the spring of 1971. He undertook some consulting contracts which took him to new areas. He went to New York State in 1971 to do a land use study in the Adirondacks. In 1972 he went to Prudhoe Bay and the Mackenzie mountains for the Canadian Wildlife Service to report on the proposed pipeline route to the Mackenzie Valley. When he had returned from Africa in 1975 he provided a report on the proposed hydro transmission corridor from Nanticoke to Pickering.

Doug received many honours. Those he prized most were the Leopold medal from the Wildlife Society and his election as Honorary President of the Federation of Ontario Naturalists. He was elected President of the Wildlife Society and a Governor of the Arctic Institute of North America. He served on the International Joint Commission. He was elected President of the Canadian Wildlife Federation, and President of the International Association of Game and Fish Commissioners. He was chosen sportsman of the year by the Outdoor Writers of Canada.

Doug had an extraordinary memory and read very widely in the classics as well as the wildlife literature. He wrote well and thought deeply about man's relationship with nature and about hunting and conservation. He continued to hunt and fish and write until his untimely death.

Doug leaves his wife Muriel, his sons Leigh, who has five children, and Stephen and a daughter Mary.

After his death the Canadian Wildlife Federation established the "Doug Clarke Memorial Award" to honour the CWF provincial organization with the most outstanding achievement in wildlife management work.

The Ontario Chapter of the Canadian Society of Environmental Biologists has also established the "CHD Clarke Award for Excellence in Environmental Biology". The recipient will have demonstrated excellence and achievement (a) in promoting and developing policies that achieved a balance among resource policies and utilization and protection of the environment and quality of life.
(b) in advancing public awareness and education on matters pertaining to the protection and management of the environment; and
(c) are members of the Canadian Society of Environmental Biologists.

Ontario Ministry of Natural Resources, Wildlife Research Contribution Number 83–03.

Bibliography of C. H. D. Clarke

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Doug Clarke left a rich record of his work and philosophy. Many contributions were not "published" in the sense used in the *Literature Cited* of *The Canadian Field-Naturalist* and other scientific journals. However, in the more flexible context of a bibliography some typescripts, departmental reports and communications and speech texts are included with the formal published citations in chronological order, in the belief that they will provide a more balanced record for future wildlife and natural historians. Entries available at the Ontario Ministry of Natural Resources Library, Whitney Block, Room 4540, Queen's Park, Toronto M7A 1W3, are marked with an asterisk (*), and those in the possession of S. R. Clarke, P.O. Box 438, Commerce Court Postal Station, Toronto, Ontario M5L 1J3 are marked with a dagger (†). A debt to the staff of the OMNR Library and to Stephen R. Clarke for documentation on material they hold, and to Arch W. L. Stewart, Natural Sciences Librarian, National Museums of Canada, for painstakingly checking numerous citations, is gratefully acknowledged.

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Report of Council to the Ottawa Field-Naturalists' Club at the 105th Annual Business Meeting 10 January 1984

Minutes of the 104th Annual Business Meeting of The Ottawa Field-Naturalists' Club 11 January 1983

Place and Time:	Auditorium, Victoria Memorial Museum Building, Metcalfe & McLeod Streets, Ottawa, 20:05 h.
Chairman:	Mr. D. Brunton, President.
Attendance:	Fifty-two people attended the meeting.

1. *Minutes of the Previous Meeting*

E. F. Pope, Recording Secretary, read the minutes of the 103rd Annual Business Meeting. It was moved by K. Strang, (2nd Laubitz) that the minutes be approved.

Motion Carried

2. *Business Arising from the Minutes*

The search continues for a permanent office for the Club. Initial leads came to nothing and the pressure of other activities impeded the search. It will be resumed next year.

The Ad Hoc Committee on the Creation of a Scholarship in the name of The Ottawa Field-Naturalists' Club presented its report to Council during the year. The Committee recommended that the Council consider establishing an endowment fund capable of providing $1500 to $2000 annually as a scholarship to a local university or to hire a summer student to do field studies related to Club objectives. The Council deferred action because of the depressed economic situation, and the significant additional funding that would be required.

The last of the raccoon dogs imported into Ontario were slaughtered for their pelts on 22 December. This removed the threat of a new species spreading through the country at the expense of indigenous wildlife and agricultural crops. The Club can take pride in the fact that it led the opposition to the establishment of these animals in Canada.

3. *Finance*

C. Gruchy presented the financial statements. He observed that the Club was in good financial condition although a slight deficit was projected for 1982/83.

The following comments were made:

(a) interest is allocated to The Ottawa Field-Naturalists' Club Account and *The Canadian Field-Naturalist* Account roughly on a 20/80 ratio, in accordance with the surpluses accumulated in each account.

(b) the income of $1174 from donations includes donations in memory of Anne Hanes, which had exceeded $500 by April. It was suggested that significant donations like this be identified in future financial statements.

(c) the expenses of $1232 associated with *The Shrike* were for entering bird record data into a computer data bank. The data can then be used for purposes other than the publication. These expenses are independent of the costs of publishing *The Shrike* which is self-financing.

It was moved by C. Gruchy (2nd Gawn) that the financial statement be accepted.

Motion Carried

4. *Report of Council*

The report was read by D. Brunton, P. Catling and C. Gruchy. After each Committee Report there was an opportunity for comments. Comments included:

(a) Birds Committee

The report omitted reference to the Highbush Cranberry bushes donated by J. Wickware for sale by the Club, proceeds to go toward bird seed.

Would a regular telephone answering service be too expensive as a temporary substitute for the Bird Hot Line?

(b) Centennial Steering Committee

It was moved by C. Gruchy (2nd Darbyshire) that the Centennial Steering Committee be commended for a very fine effort in organizing the Centennial activities.

Motion Carried

(c) Conservation Committee

Recent information indicates that the Province of Alberta is considering Mount Allen as an alternative site for the 1988 Winter Olympic Games if Sparrowhawk Mountain is found to be unsuitable. This was good news for those who feared that Lake Louise in Banff National Park would be the alternative site.

At its last meeting, the Council voted $350 to support legal expenses incurred by the Vankleek Hill Nature Society in its defence of the Alfred Bog.

The 48-hour limit on the age of snow to be dumped into the Ottawa River was an arbitrary limit based on the fact that the longer snow lies on the street the more lead, heavy metals, abrasives, salt and other contaminants accumulate.

The meeting commended the Conservation Committee for its hard work in promoting conservation.

(d) Excursions and Lectures Committee
The meeting complimented the Committee on its program for 1982.

(e) Publications Committee
It was observed that The Ottawa Field-Naturalists' Club had a number of outstanding publications and furthermore that many publishers of scientific journals do not have a publications policy statement equal to the one recently developed by the Club.

It was moved by E. Dickson (2nd Gummer) that the Report of Council be accepted.

Motion Carried

5. *Nominations*

W. Gummer, Chairman of the Nominations Committee, presented the following slate for the 1983 Council. Each candidate was introduced.

President:	D. F. Brunton
Vice-President:	P. M. Catling
Vice-President:	J. K. Strang
Recording Secretary:	E. F. Pope
Corresponding Secretary:	W. K. Gummer
Treasurer:	P. D. M. Ward

Other Council Members:

W. R. Arthurs	G. M. Hamre
R. E. Bedford	D. R. Laubitz
B. A. Campbell	P. M. D. Martin
W. J. Cody	B. M. Marwood
F. R. Cook	E. G. Munroe
S. J. Darbyshire	K. W. Taylor
E. M. Dickson	R. Taylor
S. Gawn	P. S. Walker
C. G. Gruchy	

It was moved by W. Gummer (2nd Laubitz) that the slate of nominations be approved.

Motion Carried

The President thanked the four outgoing Council members for the contribution they had made and welcomed the three new members.

6. *Nomination of Auditor*

C. Gruchy moved (2nd W. Cody) that F. M. Brigham be appointed to audit the accounts of The Ottawa Field-Naturalists' Club for the 1982-83 fiscal year.

Motion Carried

7. *New Business*

The President reported a major achievement, the publications policy statement, developed from recommendations made by the Ad Hoc Committee on Publications. This Committee had been established by the Council in November 1979. Consideration of the Club publications and development of the statement had involved many hours of deliberation over the years. It will guide Club publications in the future. The statement will be published in *The Canadian Field-Naturalist*.

Another important development during the year had been the acceptance of responsibility to host the 1983 Annual Meeting and Conference of the Federation of Ontario Naturalists. The Club had stepped in rather late, after the Federation realized that an offer to host the Conference was for 1984 not 1983. Planning for the event was well advanced.

The meeting acknowledged with appreciation the refreshments provided at the monthly and annual meetings by E. Evans and her helpers.

8. *Adjournment*

It was moved by S. Gawn (2nd Dickson) that the meeting adjourn.

Time: 21:45 h. *Motion Carried*

9. Following the business meeting a film entitled "World in a Marsh" was shown. After the film the group met for coffee.

E. F. POPE
Recording Secretary

Auditor's Report

To: Members of The Ottawa Field-Naturalists' Club

I have examined the balance sheet of *The Ottawa Field-Naturalists' Club* as at 30 September 1983 and the related Income Statements for the year then ended. My examination included a general review of the accounting procedures and such tests of the records and supporting vouchers as considered necessary under the circumstances.

In my opinion, these financial statements present fairly the financial position of the organization as at 30 September 1983 and the results of its operations for the year then ended in accordance with generally accepted accounting principles.

F. MONTGOMERY BRIGHAM

4 January 1984

The Ottawa Field-Naturalists' Club
Balance Sheet as of 30 September 1983

Assets

Current		
Cash and term Deposits	$56 660	
Accounts Receivable	27 846	
Accrued Interest	1 130	
Prepaid Expenses	905	$86 541
Fixed		
Equipment	1 705	—
Less: Accumulated Depreciation	915	790
		$87 331

Liabilities and Surplus

Current Liabilities		
Accounts Payable	$21 882	
Deferred Income	8 492	$30 374
Memorial Funds		
Baldwin	163	
Father Banim	50	213
Other Funds		
Alfred Bog Protection	1 733	
Seedathon	641	2 374
Surplus		
Balance 1 October 1982	54 146	
Expenditure over Income for Year		
The Ottawa Field-Naturalists' Club	290	
The Canadian Field Naturalist	440	
	730	
Net Income — Centennial Projects	954	
Balance 30 September 1983		54 370
Total Liabilities and Surplus		$87 331

Statement of Income and Expenditure
The Ottawa Field-Naturalists' Club
for the year ended 30 September 1983

Income			
Apportionment of Membership Fees			
Annual	$10 130		
Life	360	$10 490	
Trail & Landscape —			
Subscriptions	273		
Back Numbers	347	620	
Shrike Subscriptions		914	
Donations		613	
		12 637	
Interest		1 342	
			$13 979
Expenditure			
Trail & Landscape			
Publishing	5 683		
Circulation	283		
Editing and Office	146		
Honoraria	600	6 712	
Shrike Publishing		820	
Committee Activities — Net			
Excursions and Lectures	(190)		
Membership	820		
Macoun Club	280		
Conservation	258		
Bird Records) Bird Feeders)	15		
Publications	76		
Affiliation Fees	290		
Baldwin Scholarship	150		
Special Activities	(44)		
Council Expenses	380		
Office Assistant	390		
Office Supplies and Expenses	2 094		
Computer Charges	1 838		
Miscellaneous	380	6 737	14 269
Excess of Expenditure Over Income			$ 290

The Canadian Field-Naturalist
Statement of Income and Expenditure
for the year ended 30 September 1983

Income			
Apportionment of Membership Fees			
Annual	$6 670		
Life	240	$ 6 910	
Subscriptions		17 233	
Publication			
Reprints	8 398		
Plates and Tab Settings	4 195		
Extra Pages	16 800		
Back Numbers	338	29 731	
Other			
Interest	5 050		
Exchange	1 463	6 513	$60 387
Expenditure			
Publishing	43 121		
Reprints	4 392	47 513	
Circulation		6 420	
Editing and Expenses		1 406	
Office Assistant		2 544	
Postage		745	
Office Supplies		299	
Honoraria		1 900	60 827
Excess of Expenditure over Income			$ 440

Statement of Income and Expenditure
for the Alfred Bog Protection Fund
for the year ended 30 September 1983

Income		
F.O.N. 1983 Spring Conference	$ 3 063	
Donations	8 160	
Sale of Raffle Tickets	4 037	$15 260
Expenditures		
Land Purchase	3 152	
Testimony and legal fees	10 375	13 527
Balance 30 September 1983		$ 1 733

Report by the Council to the Ottawa Field-Naturalists' Club 1983

This report consists of reports by Committees of the Council.

Awards Committee

1983 was the second year of operation of the Awards Committee.

Nominations received in late 1982 were considered by the Committee and by Council, with the following recipients being named:

Honorary Member — Hue N. MacKenzie
Member of the Year — Roger Taylor
Service Award — William H. Knight
Conservation Award — H. Loney Dickson

The Anne Hanes Natural History Award was not awarded this year, since no candidate of suitable stature was nominated.

Certificates were presented at the 1983 Soirée in April, again with the names and dates neatly provided by Ann Gruchy. A report on the winner, with their citations, appeared in *Trail & Landscape* 17(4) and will appear in *The Canadian Field-Naturalist* [97(4): 461–463].

The Terms of Reference of the Committe have been revised according to experience, and recommendations by the previous committee.

A number of nominations are in hand for Committee consideration for 1983 awards.

W. K. GUMMER

Birds Committee

The Birds Committee is responsible for all bird-related activity within the Club. With the great interest locally in birds and birding, the Committee always has its plate full, and 1983 was no exception.

As usual, the Christmas Bird Count was the highlight of the birding year. Well over 100 persons participated again this year and were backed up by numerous feeder watchers as well. Much thanks must go to Bernie Ladouceur, Bill Coburn and Christine Hanrahan who were co-compilers of this year's count and largely responsible for its success.

The Ottawa Valley Spring Roundup in May and the Fall Count in September are popular traditions which also proved successful again this year. Thanks go to Bruce Di Labio and Bill Coburn who compiled the Spring Count and to Frank Bell who compiled the Fall Count.

This year's Owl Census, unfortunately, was not even as successful as the last. Although conditions for hearing owls seemed good on many nights, the birds remained conspicuously quiet. It now appears that the startling totals achieved in 1981, the first year for the event, may be extremely difficult to duplicate.

The third annual Seedathon was held on 11 September and was as big a hit as its predecessors. The team of Bruce Di Labio and Peter Dunn found the amazing total of 130 species, the best effort to date on this annual fund-raising event in support of Club feeders. In recognition of their many valuable contributions to the knowledge of birds, a portion of the Seedathon funds was donated to the Long Point Bird Observatory's Jim Baillie Birdathon Fund.

The three regular winter bird feeders were maintained by the Club in 1983: Moodie Drive (Jack Pine Trail), Davidson Road and Pink Road. Thanks go to the hard efforts of the individuals who keep these feeders full of food for our feathered friends: Roy Millen, George McGee, and John Dubois. In addition, a new feeder was started in Rockcliffe Park and is being maintained by Steve Darbyshire and Bill Teager. Bill Holland, Rick Leavens and Bill Miller also deserve our thanks for feeder maintenance.

The Bird Records Subcommittee evaluated a good number of rare bird reports in 1983. Exceptional records for the year including Laughing Gull, Piping Plover, Blacklegged Kittiwake, Northern Gannet and Prothonotary Warbler. The members for 1983 included Mark Gawn (chairperson), Monty Brigham, Roger Foxall, Mike Runtz, Ian Jones, Tom Hince, Bob Bracken, Bob Gorman, Roy John and Gord Pringle (Secretary).

The Ontario Breeding Bird Atlas program, coordinated locally by Bruce Di Labio, completed its third year. With the additional responsibility of assisting neighbouring areas, extra effort and more volunteers will be needed to complete our task by 1985.

The Birds Committee successfully completed a number of other tasks. The Rare Bird Alert, a telephone network for quickly informing keen birders about unusual sightings, was revised again this year. Assistance was provided for bird outings at the Federation of Ontario Naturalists' Conference hosted at Carleton University by The Ottawa Field-Naturalists' Club. Persons with birding expertise were provided for the National Capital Commission open house in Gatineau Park and the Canadian Nature Federation Festival of Feathered Friends at Lakeside Gardens.

Members of the Committee for 1983 included Frank Bell, Dan Brunton, Bill Coburn, Bruce Di Labio, Mark Gawn, Steve Gawn, Christine Hanrahan, Tom Hanrahan, Bernie Ladouceur, Gord Pringle, Arnie Simpson, Wright Smith, and Daniel St-Hilaire.

I wish to thank all Committee and Subcommittee members for helping to make 1983 another exciting and successful year of birding activity for The Ottawa Field-Naturalists' Club.

T. HANRAHAN

Conservation Committee

In 1983 the Conservation Committee continued its involvement in local, provincial and national issues. Additionally, an important development for the Committee was the formation of the Natural Areas Subcommittee with Stew Hamill as chairman. The purpose of this subcommittee is to identify and provide advice concerning significant natural areas in Eastern Ontario. As a working arm of the Conservation Committee it will also provide liaison with other organizations such as the Nature Reserves Committee of the Federation of Ontario Naturalists and the Nature Conservancy of Canada. The Kingston Field Naturalists have been invited to appoint a member to the Subcommittee and currently receive the minutes.

The major focus of the Conservation Committee's activities in 1983 was Alfred Bog. With the full cooperation of the Vankleek Hill Nature Society and assistance from many other organizations including the Federation of Ontario Naturalists, the Committee generated publicity, organized public meetings, raised funds and briefed lawyers preparatory to an Ontario Municipal Board hearing which was held at the end of May to determine the zoning for a major portion of the bog. The Ottawa Field-Naturalists' Club was very ably represented by lawyers, George Hunter and Meg Kinnear, but despite a strong case for conservation zoning the Board ruled in favour of agricultural zoning. Although Alfred Bog is now threatened with possible drainage, the issue is far from dead. The Natural Areas Subcommittee is currently developing strategy on several fronts with the ultimate aim to be the acquisition of Alfred Bog as a nature reserve. The Ottawa Field-Naturalists' Club has already purchased a 50-acre block.

Closer to home the Conservation Committee has been carrying on a dialogue with the Ontario Ministry of Natural Resources concerning the 20-year Management Plan for Torbolton Forest, near Constance Bay. At the Ministry's request, the Committee presented a plan for the management and preservation of several rare plant species which are currently eking out a precarious existence in the area. The Ministry finds the plan too ambitious but is still willing to carry on the discussion in hope of arriving at a suitable compromise.

Also on the local scene, Committee members have represented The Ottawa Field-Naturalists' Club on the Marlborough Forest Planning Committee and on committees advising Ontario Hydro concerning routes for major transmission lines from Kingston to Ottawa to Cornwall. Planning for the Cornwall hydro line has been delayed for one year but a decision on the routing of the Kingston sector is expected next Spring.

Nationally, the Conservation Committee presented a brief to the Beaufort Sea Environment Assessment panel which among other things approved tanker traffic to remove oil and gas. The Committee has accumulated a vast stack of reports and briefs on this area. Also on the National issue, the Committee has carried on active correspondence with both the Federal and Alberta governments concerning the location of the 1988 Olympic ski facilities. The main focus has been to lobby against the use of Lake Louise, which could result in severe environmental problems for Banff National Park. It now appears that Mount Allen in Kananaskis country will bear the brunt of the Olympic onslaught with only downhill activities at Lake Louise.

In addition to the above issues the Conservation Committee exchanged correspondence or commented on 22 other issues ranging from a strong protest registered against the scandalous dismantling of Conservation Lands in the official plan for the Regional Municipality of Ottawa-Carleton through to recommendations concerning the Pukaskwa National Park management plan. I wish to thank all members of the Committee for their active involvement in so many different projects.

R. TAYLOR

Education and Publicity Committee

In 1983 the Committee set up Club exhibits at the Federation of Ontario Naturalists' Annual General Meeting and Conference, at the Canadian Nature Federation's "Feed our Feathered Friends Festival", and at the Ottawa Duck Club Wildlife Art Show.

A news release concerning the FON Conference was written and distributed to the local news media. Several Club meetings and outings were also publicized during the year.

Letters offering free subscriptions to *Trail & Landscape* were sent to selected federal, provincial, and municipal politicians in the Ottawa area. The idea was that this Club publication would keep them informed of local conservation issues. Only one politician responded to the offer.

Sharon Gowan gave a talk about beaver colonies to a colony of Beaver Scouts.

Various Club sales items were put into the boutique of the National Museum of Natural Sciences for sale to the public.

Work is being resumed on a revision of the brochure *Birds, Botany and Geology in the Ottawa Region*.

Each year The Ottawa Field-Naturalists' Club awards cash prizes and one-year Club memberships to deserving exhibitors in the "Life Sciences" category at the Ottawa Regional Science Fair. In 1983 the winners were Shalini Tissaaratchy and Amanda Tower (effects of hormones and light on eggplant leaf cultures), Warren Layberry (aquatic microscopy), and Andrea McDonald and Pat Corkery (effect of burning on the

growth of grass). Shalini and Amanda were chosen by judges of the local fair to attend the Canada Science Fair in Saskatoon, where they subsequently won the Communications Award for their presentation. Jack Gillett and Fred Schueler kindly volunteered to represent the Club as judges at the local fair.

The annual Soirée was a particularly happy event for the Education and Publicity Committee, because our own Bill Knight was presented by The Ottawa Field-Naturalists' Club with the very well-deserved Service Award for his behind the scenes and in front of the scenes work. The Soirée itself typified Bill's contributions to the Club: he set up and manned the sales table for most of the evening and he had printed the award certificates which were presented that night.

I would like to thank Bill Knight and all the other members of the Education and Publicity Committee for their work during 1983.

K. TAYLOR

Excursions and Lectures Committee

Nine monthly meetings organized by the Committee featured: natural areas, wildlife management, gulls and terns, Point Pelee, Dinosaurs, Pollen, life in the soil and the Ontario Breeding Bird Atlas project. The Annual Soirée, held again at the First Unitarian Church, was a great success (see *Trail & Landscape* 17(4): 196–197). The theme of conservation was highlighted by Don Cuddy's excellent Alfred Bog display. The schedule of events for the year listed 64 outings, 7 in January-February, 7 in March-April, 33 from May to August (14 part day and 19 day or more), 13 in September-October and 4 in November-December. With regard to areas of interest there were 27 birding trips, 18 botany, 16 general, 2 insect and 1 reptiles and amphibians.

A number of our 1983 outings were described in *Trail & Landscape:* The Presqu'île birding trip (17(4): 234–235); the combined winter birding trip with the Kingston Field Naturalists (17(3): 182–183); the annual ski outing with the Thomsons (17(3): 184–185); the 1982 Thanksgiving whale outing (17(1): 36–37) and the 1982 St. Lawrence (Nairne Island) birding trip (17(2): 72). Finally those interested in the program and in the history and activities of the Excursions and Lectures Committee should read the article by Charlie Beddoe (17(1): 32–33).

We are greatly indebted to many excellent leaders and speakers, and to the National Museum of Natural Sciences for providing our meeting place and the use of the Dinobus.

P. CATLING

Report of FON Conference Committee

The Ottawa Field-Naturalists' Club acted as host for the 1983 Federation of Ontario Naturalists' Annual General Meeting, held at Carleton University, June 3-5. The theme was Springtime in the Valley. Four hundred and eighty-six people registered for the conference, 71% being from outside the Ottawa area. Indoor events included (i) the Annual Business Meeting held at the National Museum of Natural Sciences followed by a reception and evening at the museum, (ii) 20 speakers focusing principally on the natural history of the Ottawa Valley, (iii) the annual Photo Salon, (iv) a reception and banquet featuring Robert Bateman as speaker, and (v) an exhibit centre featuring displays from clubs and conservation organizations. Additionally, a very popular pre-conference feature consisted of visits to the various National Collections held by Agriculture Canada and the National Museum of Natural Sciences. A comprehensive field trip program was organized, consisting of 25 excursions, ranging from early morning bird walks through an evening of observing bats to 14 half-day and full-day Sunday trips. A total of 408 people (84% of registrants) registered for the Sunday excursions and approximately that many actually went. A registration fee of $30 was charged and a profit of $6127 was realized, half going to the Federation of Ontario Naturalists and half going to the Alfred Bog fund.

The Conference was an outstanding success because all members of the Committee worked with great enthusiasm and productivity and because more than 100 other people helped out when asked. A listing of those involved with the Conference can be found in *Trail & Landscape* 17(4): 225 (1983).

R. TAYLOR

Finance Committee

The Committee met once during the year.

Budgets were prepared for the 1983/84 fiscal year for both The Ottawa Field-Naturalists' Club and *The Canadian Field-Naturalist*. The budgets balance for this fiscal year because of a fee increase. The Committee regretted that it was necessary to increase fees but it considered the revised fees to be good value and competitive with comparable activities. No Club activities seemed easy to reduce or eliminate.

The Committee approved the changes which appear in the 1982/83 financial statements and also an increase in the Club liability insurance coverage.

W. R. ARTHURS

Macoun Field Club Committee

During the summer of 1983 the basement of the Victoria Memorial Building underwent some reorganization and the previous quarters for the Macoun Field Club were assigned for other purposes.

Although the Club was assigned space in what is now Room 15, renovations were not complete until October and September meetings were held in temporary rooms. During this time the Club's equipment, specimens, and library were in storage in the Victoria Museum Building and are only now being reorganized, a little at a time. The reduced storage space now available to the Club has meant that the Club's library and specimen collections will have to be reduced accordingly.

This is the second season for the bimonthly format of the *Little Bear*. This schedule has been very popular with the members and has fulfilled the purpose of spreading the work load of production for the organizers. This year we have been able to reduce the cost and bulk by using both sides of the paper when photocopying.

Membership is at capacity only for the junior group (33), where a waiting list of applicants has been established. The intermediate group (11) is well below capacity and the senior group (9) has less than half-a-dozen active members. Leadership for this season is primarily maintained by Stephen Darbyshire with Vic Solman helping with the senior group, and with Julia Murphy, Marianne Fournier, and Edward Kipp assisting with the younger groups. Lack of leadership seems to remain a constant threat to the future of the Club and this year is no different. The people presently most active in co-ordination do not expect to be able to continue their assistance in the future. For the present season the program remains active with an emphasis on visiting speakers and field trips.

S. J. DARBYSHIRE

Membership Committee

Membership in the Club continues to increase steadily. Non-local membership declined by six but local membership increased by 38. The number of new members joining the Club in 1983 was 197, an increase of 5 over 1982. The total membership in the Club as of December 1983 was 1278, an increase of 32 over the 1982 total of 1246. Family membership totalled 322. Based on an average of 2 members per family, we estimate the total membership served by the Club to be 1600.

Table 1 shows a tabulation of membership distribution. The figures in brackets contain 1982 totals.

Hue N. Mackenzie, an esteemed Club member for over 20 years was elected Honorary Member for 1983.

The 1982 Volunteer List was updated by the addition of 34 new volunteers. These lists are circulated to all committees of the Club. The volunteers have a broad diversity of knowledge and experience which can be of significant benefit to the Club.

Due to the increased postal costs, membership cards again were mailed with the 1984 membership renewal forms, thereby reducing expenses by approximately $400.00.

The Membership Committee assumed responsibility for the 1983 FON Conference Registration process which was very ably coordinated by Barbara Martin, assisted by Ellaine Dickson and Barbara Campbell. Thanks go to all for contributing so much time and effort to successfully accomplish the mammoth task of registration.

A supply of membership application forms was reprinted with the updated membership rates.

By-Law 15 was changed by the Council to read "The spouse of a life member shall be granted family membership status upon payment of annual dues of $5.00 but not receive the regular Club publications."

Lastly, I wish to thank all the members of the Committee for their support and assistance: Ellaine Dickson, Fran Goodspeed, Luella Howden, Vi Humphreys, Barb Martin, Aileen Mason, Bette Stern, Ken Strang, Roger Taylor and Peter Walker. I wish to thank Patricia Narraway for continuing to oversee the computer programs.

B. CAMPBELL

TABLE 1. Membership in The Ottawa Field-Naturalists' Club, 1983.

	CANADA				FOREIGN					
TYPE	LOCAL		OTHER		USA		OTHER		TOTALS	
Individual	482	(476)	318	(323)	78	(80)	6	(5)	884	(884)
Family	291	(264)	28	(29)	2	(2)	1	(0)	322	(295)
Sustaining	23	(15)	2	(2)	1	(0)	0	(1)	26	(18)
Life	10	(13)	18	(16)	3	(3)	1	(1)	32	(33)
Honorary	10	(10)	3	(5)	1	(1)	0	(0)	14	(16)
	816	(778)	369	(375)	85	(86)	8	(7)	1278	(1246)

Publications Committee

The Publications Committee continued its role as advisory body to the Council on the Club's publications.

This has been a difficult year for *The Canadian Field-Naturalist*; its publication has fallen well behind schedule. The chief reasons for delays were a lack of continuing assistance to the editor in the important areas of proof-reading, secretarial, and clerical duties and, early on, other job-related commitments of the editor. Only two issues appeared in 1983: Volume *96*, issue 4, and Volume *97*, issue 1, comprising a total of 290 pages, 22 articles, 19 notes, 45 book reviews, 1 commemorative tribute, several pages of notes and comments, and a listing of 182 new titles. Efforts are underway to provide suitable editorial assistance and we hope that publication will be back on schedule soon. The processing of Volume *97*, issues 2–4 is in an advanced stage. We expect these to appear early in 1984, following one another at brief intervals. There was no change in the Associate Editorships, neither was funding from external sources required.

Volume *17* of *Trail & Landscape* was published, comprising five issues with a total of 272 pages. The highlight was the 88-page issue 3 to complement the Club's hosting of the Annual Conference of the Federation of Ontario Naturalists. This issue carried several articles relevant to the conference topics. Another fine article in the "field guide" series also appeared: "Pondweeds of the Ottawa District" by I. Dobson and P. Catling. There were no changes in editorial staff. We expect that Volume *18* in 1984 will be somewhat reduced in total paging from the previous two volumes.

Six issues of *The Shrike* appeared in 1983 — Volume *7*, issues 5, 6 and Volume *8*, issues 1–4, with a total of 175 pages. Written, graphical and tabular accounts of bird sightings in the Ottawa area were continued. The editor, Tom Hanrahan, served notice that he would relinquish this position with the completion of Volume *8*. Search for a new editor is in progress. We thank Tom for his service to *The Shrike*. It is probable that future issues may be leaner in paging than in the past.

One manuscript is under consideration for publication as a special publication.

The costs of publishing are sky-rocketing. It is not yet clear how and to what extent this will affect our Club publications, but changes will undoubtedly be necessary, either in funding mechanisms or paging.

The Publications Committee thanks the editorial and production staffs of all three journals for their continued dedicated service to the Club.

R. E. BEDFORD

Study Groups

The botany study group advertised two events as part of the general program and had several other meetings. The bird study group also had several meetings. The butterfly and insect study groups were less active. The prevailing interest in the study groups has been entertainment rather than study and this has placed excessive pressure on leaders. Only the botany and bird study groups can be said to have experienced any degree of success in terms of studying.

P. CATLING

Book Reviews

ZOOLOGY

Goodbye Bugs: A practical guide to coping with insects in the great outdoors

By Alan West and Bev Smallman. 1983. Grosvenor House Press, Toronto/Montreal. 144 pp. $8.95.

This useful little book is intended as a layman's guide to dealing with pest or nuisance insects in Canada and the northern United States. Though the emphasis is on insects encountered during outdoor activities, many of the more common household pests such as flour beetles and cockroaches are also considered.

The book begins by educating the reader about the types of insects likely to be encountered and the general principles of insect control. From there, the authors move on to deal with specific insects, providing in each case a description of their habits and life history, and in light of these, the most effective means of dealing with them. In the case of insects in the out of doors this advice generally comes down to 'protect yourself', while indoors (cottages, tents, etc.) the common-sense solutions such as proper screens as well as repellents and other sprays are the ones most often recommended.

The very real dangers of severe reactions to insect bites and the possibilities of transmitted diseases are also treated in detail. In particular, the authors emphasize the importance of prompt action in these cases.

Written in a very relaxed style, the book is not only informative but also entertaining. As one would expect in a book of this nature, the use of jargon has been kept to a minimum and in no instances were terms left unexplained.

Perhaps the greatest service the book provides is the psychological reassurance it gives. Armed with this book the reader will feel more at ease in the outdoors and, while there is still not much he can do about the hordes of mosquitoes and their like, he at least will know the why's and how's of what they do and why they do it.

REIN JAAGUMAGI

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Biology of Desert Invertebrates

By Clifford S. Crawford. 1981. Springer-Verlag, Berlin, Heidelberg, New York. xvi + 314 pp., illus. U. S. $39.30.

Deserts and desert invertebrates have received increasing attention from biologists over the years as man's activities result in increasing desertification in many areas of the world, and as the fascinating details of the biology of desert life are unveiled. In *Biology of Desert Invertebrates* Dr. Crawford presents a thorough review of our knowledge of these often overlooked components of arid ecosystems. Although primarily intended as a book for researchers and students of desert biota, it is almost certain to fulfill the author's hope of appealing to serious naturalists as well.

The book is divided into five parts. The first part, Perspectives, is divided into two chapters. Chapter 1 provides an overview of the nature, origins and distribution of the worlds deserts. Most Canadian readers probably need to be reminded, as I did, that virtually all of the District of Franklin and much of the Ungava Peninsula are polar deserts. These areas receive very little precipitation and are so cold throughout the year that most moisture is in the form of ice, which is virtually useless to plants and animals. This section is followed by a too short discussion of desert climate. In Chapter 2 the emphasis shifts to a quick review of the invertebrates that live in deserts.

Parts 2 through 4 comprise the bulk of the book. Part 2, Adaptations to Xeric Environments, consists of five chapters and is a discussion of morphological, physiological, and behavioral mechanisms adopted by different species to reduce water loss, remain in a favorable microhabitat, and acquire energy while avoiding unnecessary exposure to predators. Much of the discussion concerns behavioral adaptations, but in the summary to Part 2, Dr. Crawford points out that evolutionary success depends on a complex set of factors which includes the morphological and physiological adaptations, as well as the behavioral ones.

The next four chapters comprise Part 3, Life-History Patterns. The author discusses the importance of timing of reproduction and development, and differences in patterns of resource utilization among species with various life-history strategies. The highly

unpredictable nature of desert environments often results in the development of mechanisms closely related to the timing of precipitation and plant growth.

Part 4, Invertebrate Communities: Composition and Dynamics, provides data to support the author's central theme that desert invertebrates contribute significantly to the structure and function of arid ecosystems. This section is divided into six chapters. The first three deal with different soil and litter communities. The next two treat temporary vegetation and perennial shrub communities, respectively, and the last examines the invertebrate communities of temporary water. In each chapter communities characteristic of the different habitat types are detailed, and their responses to difficulties and opportunities are explored.

Part 5 is a summary of the rest of the book. Dr. Crawford reviews the involvement of desert invertebrates with the resources available to them and presents a compartment model of a desert ecosystem that stresses the role of invertebrate consumers. Not surprisingly, he concludes that invertebrates are indeed important components of desert ecosystems. He then suggests possible directions for future research.

Biology of Desert Invertebrates is an excellent book. It is well written, well organized, and well illustrated. Whether or not you have a professional interest in desert invertebrates, you can hardly fail to become intrigued with them after reading Dr. Crawford's clear and enthusiastic presentation. I highly recommend this book to anyone with an interest in natural history.

CHARLES R. PARKER

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Estrildid Finches of the World

By Derek Goodwin. 1982. British Museum (Natural History), Comstock Publishing Associates, a division of Cornell University Press, Ithaca, New York. 328 pp., illus. U. S. $45.00.

The estrildid finches are small sparrow-like birds comprising almost 140 species. They occur in the Palearctic, Ethiopian, and Australasian regions, including some Pacific islands. Several species have for a long time been very popular as cage birds and three species have become domesticated. Few other authors would have been as qualified as Derek Goodwin, the author of two other important monographs, to treat this diversified group.

In the Introduction, the author discusses the relationships of the Estrildidae, particularly in relation to the Viduinae (Ploceidae) of which some species are parasitic on estrildids, but there is still much controversy about the evolution and taxonomy of these two groups. In the first and second chapters, the nomenclature (genera, species, subspecies, and varieties), the distribution, and adaptive radiation are treated briefly. The third chapter deals in less than four pages with "Plumage and coloration". The fourth chapter (p. 20-50) is entitled "Behaviour and biology"; in it the author treats many aspects of behaviour such as feeding habits, drinking, plumage care, nesting, parental care, behaviour of the young, 'cock nests', and nest 'decorating', nestling mouth patterns, display, and voice. Each subsection is followed by a list of references. Chapter 5 is entitled "Estrildids in captivity" and summarizes in a few pages (p. 51-64) the care and maintenance of these birds in captivity and contains much useful information. Chapter 6 entitled "The estrildid finches" runs from page 65 to page 319. It is the book! These finches are divided in sub-groups, such as the 'ant-peckers', 'the firefinches', the 'parrot-finches' to name only a few, and each sub-group is introduced with a few paragraphs describing its characteristics and taxonomic position when applicable. Then each species is treated individually and the format is as follows: description, field characters, distribution and habitat, feeding and general habits, nesting, voice, display and social behaviour, other names, and references. A clear and good size distribution map complements the section on distribution. I found it clear and very useful. The author has succeeded in summarizing the information available on each species in a clear and informative text. The book contains eight pleasant color plates of good quality by Martin Woodcock and numerous line drawings illustrating species or peculiar behaviour patterns.

The author is to be congratulated again for having produced another excellent monograph and it is with pleasure that I recommend this book to all who are interested in this group of colorful birds.

HENRI OUELLET

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A. B. A. Checklist: Birds of continental United States and Canada

By G. S. Keith, L. G. Batch, D. D. Gibson, R. G. McKaskie, C. S. Robbins, A. Small, P. W. Sykes, and J. A. Tucker. 1982. Second edition. American Birding Association, Austin, Texas. 80 pp. U. S. $9.00 plus $2.25 shipping.

The American Birding Association (ABA) brought out its first checklist in 1975. It included continental North America and 100 miles of offshore waters, but excluded Greenland, Bermuda, Baja California, Mexico and Hawaii, the first three of which had been included in all five checklists published by the American Ornithologists' Union (AOU) since 1886. The ABA introduced a few sensible changes in species names, such as Long-billed Marsh Wren to Marsh Wren and Short-billed Marsh Wren to Sedge Wren.

The ABA second edition lists 838 species in comparison with 794 in the first. Seven were added by "splitting" of species previously considered single and nine were lost due to "lumping" of previously separate forms. Two met the criteria for introduced species, three were deleted on the basis of insufficient evidence, and 47 were acceptable records of species never before seen in the region.

The ABA has issued yearly supplements in *Birding* and has had a plan to issue a new edition every five or six years. Adherence to this plan presumably explains why the ABA rushed a second edition into print, only a year before publication of the more authoritative and much more extensive 6th AOU Check-List (which now includes Hawaii and Central America to Panama, but for the first time excludes Greenland). The ABA saw the final draft of the AOU list, as the preface to the ABA Checklist explains, but "since the ABA list was already in galley form . . . it was possible to adopt only a few of the more important changes." Unfortunately, the ABA thereby debased its own product and guaranteed its obsolescence within the year. Clearly there can be only a single authority for bird nomenclature; in North America it is the AOU.

Undoubtedly there is a market for a convenient list of the birds of the continental United States and Canada. The AOU recognized this in 1935, by issuing an "Abridged Check-List of North American Birds," a pocket edition "prepared for the convenience of those who require for record purposes a complete catalog in condensed form." The same useful function could have been served by the ABA, by nothing more than resetting type to place all species in their new order with appropriate changes in scientific names, which the AOU had generously given permission to use. Such a format, promised in the third edition, would double as a life-list record and as a quick, authoritative reference source. It is too bad that the prudent birder has another five or so years to wait.

C. STUART HOUSTON

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Wild Mammals of North America: Biology, management and economics.

Edited by J. A. Chapman and G. A. Feldhamer. 1982. The John Hopkins University Press, Baltimore. 1147 pp. U. S. $50.00.

There has been a need for some time now for a major work on mammals which includes a detailed description of each species, describes its biology and discusses management techniques and research. *Wild Mammals of North America* fills that void and represents a major contribution to reference literature on mammals. Students, teachers, professional biologists and naturalists will benefit from use of this book.

Included are most wildlife species which are of economic importance or which in the opinion of the editors "biologists and naturalists are most likely to be involved with" (p. ix). Families entirely absent include: Sorcidae (shrews), Ochotonidae (pikas), Heteromyidae (pocket mice and kangaroo rats) and Dipodidae (jumping mice). In addition, within the family Muridae only *Microtus* species are discussed. Presumably groups were omitted due to their lack of economic importance. However, one could easily argue for inclusion of at least *Peromyscus* within the murids (due to seed predation on coniferous species). Good arguments could probably be mounted for inclusion of the other groups as well, if only for the sake of completeness.

Chapters are organized by species and each is authored by a recognized authority on some aspect of the biology of that species. The chapters are extensive and generally organized by headings titled: nomenclature, distribution (including a small map), description, physiology, reproduction, ecology, food habits, behaviour, mortality, sex and/or age determination, economic status and management, current research and management needs and literature cited. Of course, depending on the species, these topics are more or less well understood. For the better known species, sections are also included on population

dynamics, evolution, various capture and marking techniques, and research. Within this framework the literature on each species or groups of similar species is summarized, and previously unpublished information is often included as well. The sections dealing with reproduction, ecology, behaviour and mortality are generally excellent and will enable the reader to acquire a fairly detailed knowledge of the species. "Reproduction" covers breeding behaviour, timing of events, lactation, growth rates, and sexual maturity. Under "Ecology" habitat, home range, density, movements, and an often detailed discussion of food habits are included. Behaviour for some species is better researched than for others, and for those species this section is well done. For example, diagrams of various threat and maternal postures of Caribou, *Rangifer tarandus*, are shown. Other behaviours discussed include both intra- and inter-specific activities such as territoriality, courtship, and anti-predator behaviour. Mortality patterns are often not entirely known but this section includes good discussions of the effects of man, diseases, parasites, and predators. The discussions of management of the various species are somewhat lacking and generally of little value to working biologists.

A couple of organizational and editorial aspects detracted somewhat from this book. The first is lumping of species in the same chapter, such as bobcat and lynx. The reader will sometimes become confused as to which species is being referred to in these chapters, and grouping does not underscore fundamental differences between species. In the case of the Black-footed Ferret (*Mustela nigripes*), a chapter separate from weasels is probably warranted in view of its endangered status. On the other hand, the chapter on voles (*Microtus* spp.) does actually benefit from discussing these species together; differences are clearly presented here. A second organizational problem is the differential treatment of certain topics among chapters. This results in some extremely long chapters while other equally well-researched species are not covered in the same depth. A consistent approach to the discussion of morphometrics, population control, and population dynamics would improve this book. The chapters on Wolves (*Canis lupus*) and Black Bears (*Ursus americanus*) were lacking on the latter two subjects, for example. Another improvement would be the inclusion of larger, more accurate range maps. From a Canadian point of view, the book could have been more valuable as many of the habitat descriptions bear little resemblance to habitat use in the boreal forest (eg. Black Bears) or at the northern extremities of ranges. Some errors of omission occur both on the range maps and in the text because Canadian literature was not researched. For example, the chapter on horses fails to report that wild horses have been studied in Alberta and on Sable Island. Editorial errors are remarkably few for a volume of this size but vary among the chapters. Some are error-free while others, such as the section on Marten (*Martes americana*), suffer from several.

On the whole these criticisms are minor in comparison to the immense value of this book. The editorial achievement of gathering these chapters together is tremendous. Biologists and naturalists will enjoy the generally well-researched nature of the text; researchers and managers will benefit from discussions of techniques and research needs; and students will appreciate the wealth of knowledge in a single location. This is a reference book which should be on the shelves of most serious people in these groups. I highly recommend this book.

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Marine Birds and Mammals of Puget Sound

By Tony Angel and Kenneth C. Balcomb, III. 1982. Washington Sea Grant Program (Available from University of Washington Press, Seattle) xiii + 160 pp., illus. U. S. $14.50 plus $1.75 postage.

The authors have aimed this handsome book at environmentalists, planners, and politicians, the people whose decisions can directly affect the marine birds and mammals of Puget Sound. They correctly point out that, from the first appearance of Europeans in the area, there has been constant pressure on species' populations and their habitat through exploitation, disturbance, and habitat alteration and destruction. They hope this attractive book will help develop people's awareness and increase their understanding of the natural history and habitat requirements of Puget Sound marine bird and mammal species. To these ends this book is well on its way, and is a definite positive contribution.

The book starts with well-done short general sections on wildlife heritage, the major marine habitats, habitat modification, pollution, and people pressure, with graphic examples of each from Puget Sound. The text concludes with an appendix of seven summary tables and seven maps. These tables graphically

depict, by species groups, the importance of habitats for feeding, nesting, and resting; the impact of human activity through habitat loss, pollution, and people pressure; the annual occurrence by month; the microhabitat use of each major habitat with lists of plants, invertebrates, fish, birds, and mammals found there; and a table of life history notes of marine mammals. The figures graphically show bird areas, pinniped haulouts, cetacean sitings, eelgrass beds, kelp beds, and marshes. The book ends with a selected bibliography.

The main portion of the book, 110 pages, is taken up by species accounts of marine birds and mammals commonly occurring in Puget Sound. Each group is preceded by a general family description including natural history, occurrence, and impressionable personal accounts. Each species documentation includes a small distribution map, and discussion of status, distribution, food, and critical habitat.

At the general level it is hard to fault this volume. But in the specifics there are many problems. The small range maps are without explanation. The meaning of the dots appearing on them seemingly does not relate to any aspect of distribution of the respective species in Puget Sound. The maps were evidently prepared without regard to the published literature available, and are in their present form useless and completely misleading. The status and distribution accounts are superficially accurate, but the choice of location examples is poor and generally inaccurate and also misleading. The accounts of nesting sites of local breeding birds are inaccurate, including crediting nesting to an island that does not exist, to islands species are absent from, or omitting major colonies. The literature that is cited demonstrates a poor understanding of the species and the available literature.

The cover and pages are graced with over 100 of Tony Angell's attractive and very well done drawings of marine birds and mammals. For his followers and those who enjoy good wildlife artwork, these drawings alone make this volume a worthwhile acquisition. However, many of his depictions are stylized, with the postures presented not typical, or even known.

Overall the authors and the publisher are to be credited for producing a very attractive and useful volume, for the lay public. But it is doubtful it will be useful to the informed environmentalist or, most importantly, the planner and the public office holder.

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Migration, Harvest, and Population Dynamics of Mourning Doves Banded in the Central Management Unit, 1967–77

By James H. Dunks, Roy E. Tomlinson, Henry M. Reeves, David D. Dolton, Clait E. Braun and Thomas P. Zapatka. 1982. United States Fish and Wildlife Service, Special Scientific Report — Wildlife No. 249. 128 pp. Free.

This comprehensive monograph co-authored by three federal and three state biologists, provides much important information in 37 pages. Since the Mourning Dove is not a game bird in Canada (except in British Columbia since 1955), most Canadians will be amazed to learn that ". . . more doves are now taken by hunters on the North American Continent than any other single game bird" — 48 million annually in the United States alone. Since the total population is about ten times this number, the authors estimate that such a bag can be sustained indefinitely without affecting population totals.

Such hunting pressure in turn is sustainable only because the mourning dove has increased greatly with agriculture (and, though not mentioned, has extended its range since settlement). Waste grains form a major food supply, while clearing of dense forests and planting of trees have increased favourable "edge habitat." Planted trees have provided improved nest sites, but recent bulldozing of such trees in now-deserted shelterbelts has been detrimental.

Mourning doves have been banded in large numbers, 868 000 in the United States in only nine years. The 332 314 doves banded in the 14 states of the Central Management Unit by federal and state wildlife biologists, in a cooperative program, form the basis of this report. Of the 9067 recoveries to date, 5266 were "direct recoveries" taken within the first hunting season after banding. All but 2 or 3% had been shot by hunters, with 44% from Texas and 15% from Mexico and Central America. The results are summarized and displayed on 14 useful maps. A further 87 pages of detailed tables are provided in Appendix A.

There is pressure to open a season on doves in some other Canadian provinces. Before you make your decision, read this informative report.

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Amphibians and Reptiles of New England: Habitats and natural history

By Richard M. DeGraaf and Deborah D. Rudis. 1983. The University of Massachusetts Press, Amherst. 85 pp., illus. Cloth U. S. $14.00; Paper $6.95.

For years a colleague has curtly observed that the herpetology of Maine is the poorest-studied of any "Canadian" region. This comment could be extended to much of northern New England. Although the majority of all the herpetologists who have ever lived may currently base themselves in the United States, they largely equate an areas' scientific interest and importance with the diversity of its species and habitats and are drawn magnetically south to Mexico, Central America, and, increasingly in recent years, to South America and Australia.

DeGraaf and Rudis, graduates of the University of Massachusetts and the University of New Hampshire, respectively, have tried to fill the vacuum with a "New England coffee-table book" (large — 21 × 16 cm — format but with frugal-Yankee black-and-white illustrations throughout). Not only are the oft-neglected Maine, New Hampshire, and Vermont covered but also the better researched "southern" states of Connecticut, Massachusetts, and Rhode Island.

Apparently it has grown from the authors earlier *Forest Habitat for Reptiles and Amphibians of the Northeast* (1981) which was criticized by James D. Lazzell (Copeia 1982(3): 734–736), and that review should be referred to as a caution in reading the acknowledgments.

A preface lays out the authors' orientation to habitat and land use, and underscores the need for further study of them for balanced rational planning of future conservation in the area. A ten-page introduction explains the sources, gives a historical perspective (the literature from 1622), and presents a summary of physiography, climate, and vegetation. Here also is a detailed listing of status ratings in all states included for species of special concern together with the varied definitions of the categories.

A one-page checklist gives 56 taxa to be considered (15 salamanders, 11 anurans, 13 turtles, 1 lizard, and 16 snakes). A single page introduces each subsequent section (orders, or in the case of lizards and snakes, sub-orders) and within the sections usually one page is devoted to each taxon.

The accounts are rigid: range (in North America), relative abundance, habitat, special habitat requirements, age/size at sexual maturity, breeding period, egg deposition, number of eggs/mass (amphibians), clutch size (reptiles) or number of young (some snakes), young born (some snakes), eggs hatch, larval (salamanders) or tadpole (frogs) period, home range/movement, food habit/preferences, comments, and selected references. In addition, each account has a black-and-white drawing of an adult and a distribution map showing the hypothetical New England range (shaded) and county records (dots). Wherever possible, the data given are from New England populations, but the scarcity of such data sometimes requires citations of studies in geographic areas far removed, usually with the state indicated.

The book concludes with an eight-page bibliography of 365 titles and a one-page glossary of 40 items.

For description of morphological variation the reader is referred to the standard field guides; only size is included and breeding calls are omitted with every other identification character. Recognition depends solely on artist Abigail Rorer whose illustrations vary from good, particularly for many salamanders and some frogs and turtles, to plain awful. The scalation of lizards and snakes is suggested by vague hatching. Some distinctively blotched species (Water, Milk, and Hognose snakes) are recognizable but others are not. The Redbelly Snake appears to have been skinned and the Smooth Green Snake and the Black Rat Snake also are failures. The Mudpuppy has only a faded trace of pattern, but fortunately its form is distinctive. The "Mink Frog" drawn may have actually been a heavily mottled Green Frog — there is little indication of the horizontal hind leg blotches that distinguish most Mink Frogs, whereas the vertical leg bars distinctive of Green Frogs are indicated, at least in the upper part of the hind leg. Although two subspecies in New England are supposedly represented by illustrations in both Garter Snake and Ribbon Snake accounts, in neither can the races be distinguished by the vague depictions.

Separate accounts are presented for each of two subspecies for the Painted Turtle, Garter Snake, and Ribbon Snake creating an illusion of ecological distinctiveness. These geographic races are connected by populations intermediate in both morphology, life history, and habitat. The authors' confusion is further indicated as the account of the Eastern Painted Turtle begins, and the one for the Midland Painted Turtle concludes, with similar statements that no pure stocks of either subspecies exist in New England. Michigan and Wisconsin population studies cited in the account for the eastern race are far west of any expected influence from it. Another justified pooling would have been to place the triploids associated with *Ambystoma jeffersonianum* and *A. laterale*, "*A. platineum*" and "*A. tremblayi*", respectively, into the former two species accounts. The elevation to species status for these has long since served the laudable, at the time,

purpose of focusing geographic and ecological attention on them, and they may now be included with their parental taxa like other hybrids.

There are irritating slips in citing old information under the incorrect form — the reference to *A. jeffersonianum* habitat for egg deposition credited to Bleakney (1957) pertains to populations we are now reasonably certain are *A. laterale* and its triploid, for example. A different case is an outdated reference to Leopard Frogs hibernating "in mud". Emery, Berst, and Kodaira (Copeia 1972: 123–126) have since observed these frogs wintering on top of the mud in small pits, sometimes lightly covered with silt but not *in* the mud.

Of Canadian species occurring east of central Ontario only the Chorus Frog, *Pseudacris triseriata* is missing*; and only three species of salamanders, one anuran, two turtles, and two snakes included here fail to reach Canada. Despite a poverty in Canadian references it would be a useful addition to the library of Canadian herpetologists, naturalists, or resource-oriented biologists provided they use it only as a guide to the literature, and check each source. Some citations are incorrect and others out-of-date, either in data or taxonomy. It is a pity that such potentially useful compilations are left to the well intentioned but poorly trained, but commendable that they are at least tried by someone. This should be a catalyst to production of better books by others and by the authors themselves.

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**Pseudacris triseriata* actually does occur in northwestern New England. A previously unpublished record in the National Museum of Natural Sciences, National Museums of Canada (NMC 16840) is of four males and one female collected from a breeding site (*Typha* and grass marsh) 29 April 1975, 3 km SE of Alburg (junction Hwys 2 and 78), Vermont: Frederick W. Schueler.

Walker's Mammals of the World — Volumes I and II

By Ronald M. Nowak and John L. Paradiso. 1983. Fourth Edition. The John Hopkins University Press, Baltimore and London. 1472 pp., illus. U. S. $65.00.

Walker's Mammals of the World is a well-known reference work that needs no introduction. The first edition of this comprehensive work appeared in 1964 and several new editions have followed since at intervals of four, seven and eight years. Considering the size and scope of the book, this is a remarkable feat. The fourth edition represents a virtual rewriting of the text by Nowak and Paradiso, who succeeded in producing two volumes that are not only up-to-date but better and more useful than previous editions.

The two volumes treat 1018 genera and 4154 species of mammals. This total includes 17 new genera named after the third edition appeared in 1975 and one genus, *Catagonus*, a peccary previously known only from subfossil remains, but discovered alive in the seventies. Undoubtedly one of the most remarkable discoveries of the decade.

The text follows a systematic format. Sections dealing with orders and families give information on systematics, morphological characteristics, general ecology and behaviour, and the geological range. The accounts of the genera are similar in format but more detailed. Each account begins with a discussion of the systematics of the genus including a list of species with their distribution, followed by a description of the genus, and information on ecology, behaviour and reproduction of one or more species in the genus. A useful addition for conservationists is the addition of the status assigned by the International Union for the Conservation of Nature (IUCN) and U.S. Department of the Interior (USDI) to species whose present distribution and abundance are a cause for concern. The listing of species on Appendix 1 or 2 of the Convention on International Trade in Endangered species of Wild Fauna and Flora (CITES) is also given. Information on the geological range of the genus, if available, is included as well. As in previous editions each genus is illustrated by photographs, including many new and additional ones, of one or more of its species. The illustrations are on the whole of good quality and add greatly to the value of the book.

Aside from the addition of much new information the volumes' usefulness is much enhanced by the inclusion of recent bibliographic references in the text. I feel no hesitation in recommending these volumes to all who are interested in mammals. The price, by today's standards, is more than reasonable and makes these two volumes a real bargain.

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The Hummingbirds of North America

By Paul A. Johnsgard. 1983. Smithsonian Institution Press, Washington. 303 pp., illus. U. S. $35.00

This book, according to the text of the jacket, is the "first comprehensive summary of North American hummingbird biology in more than 40 years . . .". It comprises two parts: "Comparative biology of the hummingbirds" divided into six chapters, and "Natural Histories of North American hummingbirds" which deals with the 23 species considered to occur in North America. This part is followed by six appendices, a glossary, a bibliography, and an index. In the first chapter (pages 17-25) the author discusses classification, distribution, and general attributes, on the basis of information obtained mainly from the literature. The evolution and speciation of the family is briefly dealt with in Chapter Two (pages 26-32), whereas "Comparative Anatomy and Physiology" are dealt with in less than 10 pages in the next chapter. Chapter Four is too brief (pages 43-50) to deal adequately with comparative ecology. A similar remark applies to Chapter Five, "Comparative Behavior" and Chapter Six, "Comparative Reproductive Biology" which are treated in less than 14 pages, including abundant illustrations and two tables.

In part two, the 23 species of hummingbirds found in North America (including Central America and the Caribbean islands) are treated as follows: other names, range, North American subspecies, measurements, weights, description, identification, habitats, movements, foraging behavior and floral ecology, breeding biology, and evolutionary and ecological relationships. The breeding range, in addition to the short text provided for each species, is illustrated in all cases on a full-page map, enhanced with a pleasant line drawing of the species by artist James McClelland. The major part of the information condensed in these sections is the result of compilations from the literature. I have the impression that the appendices were, for the most part, added to increase the size of the book. The bibliography is incomplete and at least one important monograph was left out (E. Mulsant, 1874–1878, Histoire naturelle des Oiseaux-Mouches ou Colibris, constituant la famille des Trochilidés). I found several typographic errors and misspellings, even some in the names of authors. The 16 color plates by James McClelland are attractive and colorful, although I found the plain white background somewhat disturbing in a few cases. The artist must be congratulated warmly for the great detail and accuracy of each specimen illustrated. The plants and flowers shown are of very high quality and pleasing.

The main merit of this book is to have assembled a great deal of current information about North American hummingbirds. It should be useful to those who wish to obtain information on these birds rapidly without having or being unable to consult original references, which I recommend strongly. The information could have been condensed more, and the book could have been smaller, without the appendices and the loose page lay-out. This may have contributed to bring its price down considerably. However, the production (paper, printing, binding, design) is of an excellent quality.

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BOTANY

Flora of Alberta

By E. H. Moss. 1983. Second edition, revised by John G. Packer. University of Toronto Press, Toronto. 687 pp. $45.00.

This is a manual of the flowering plants, conifers, ferns, and fern allies growing without cultivation in the Province of Alberta. In it, a total of 113 families, 547 genera, and 1755 species are keyed and described. It is an update from the 1959 edition in which 104 families, 499 genera, and 1605 species were treated.

The basic format of the book has remained the same. The keys have been revised to include the additional species and changed taxonomic concepts, and are now in the form of adjacent couplets, rather than being indented. This has the advantage of saving space, but is harder to follow. Somatic chromosome numbers have been included where known, those based on Alberta material being identified by an asterisk. The overall distribution of each species is given and the habitat information has been refined. The Alberta distributions of the native species have been presented on 1158 maps, 24 to a page in a section at the back of the book. The dots, circles and triangles unfortunately are not always readily distinguishable without the use of a lens, but these maps are a most

important addition to the manual. Another innovation is a short introduction in which the topography, soils, and vegetation are described and mention is made of some notable collectors and authorities for Alberta species.

This updated flora is a welcome addition to our knowledge of western Canadian botany. It will be most useful to students and professional botanists both in the province and in adjacent regions as well as plant geographers studying the North American flora.

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NEW TITLES

Zoology

*__Advances in herpetology and evolutionary biology: essays in honor of Ernest E. Williams.__ 1983. Edited by Anders G. J. Rhodin and Kenneth Miyata. Harvard University Museum of Comparative Zoology, Cambridge. *xx* + 725 pp., illus. U.S. $69.

*__Amphibians and reptiles of Nova Scotia.__ 1984. By John Gilhen. Plus poster by Fred Scott. Nova Scotia Museum, Halifax. 176 pp., illus. Cloth $29.95; paper $19.95; poster $2.95.

Animals as navigators. 1983. By E. W. Anderson. Van Nostrand Reinhold, New York. 207 pp., illus. U.S. $19.50.

†**Animal signatures.** 1984. By Edward Claridge and Betty Ann Milligan. Nova Scotia Museum, Halifax. 54 pp., illus. $2.95.

The behavior and ecology of the African buffalo. 1983. By Mark J. Mloszewski. Cambridge University Press, New York. x + 256 pp., illus. U.S. $37.50.

†**A bird-finding guide to Canada.** 1984. By J. Cam Finlay. Hurtig, Edmonton. 387 pp., illus. Cloth $27.95; paper $18.95.

*__Birding with a purpose: of raptors, cabboons, and other creatures.__ 1984. By Frances Hamerstrom. Iowa State University Press, Ames. *viii* + 130 pp., illus. U.S. $13.95.

†**Bird navigation: the solution of a mystery?** 1984. By R. Robin Baker. Holmes and Meier, New York. x + 256 pp., illus. Cloth U.S. $32.50; paper U.S. $24.50.

*__Bird songs and their meaning.__ 1984. By Rosemary Jellis. Cornell University Press, Ithaca. 256 pp., illus. U.S. $14.95.

The deer wars: the story of deer in New Zealand. 1983. By Graeme Caughley. Heinemann, Auckland. *viii* + 187 pp. + plates. U.S. $17.95.

Elements of an agreement on the conservation of western palearctic migratory species of wild animals. 1983. By the International Union for Conservation of Nature and Natural Resources. Unipub, New York. 57 pp. U.S. $8.

Evolutionary genetics of fishes. 1984. Edited by Bruce J. Turner. Plenum, New York. c630 pp. U.S. $79.50.

Fossils for amateurs: a guide to collecting and preparing invertebrate fossils. 1983. By Russell P. MacFall and Jay Wollin. Second edition. Van Nostrand Reinhold, New York. *x* + 374 pp., illus. Cloth U.S. $18.50; paper U.S. $12.50.

The fox. 1982. By Margaret Lane. Dial, New York. 32 pp., illus. Cloth U.S. $9.95; paper U.S. $3.40.

An introduction to the economics of fisheries management. 1983. By W. C. MacKenzie. Fisheries Technical Paper No. 226. United Nations Food and Agriculture Organization, Unipub, New York. 31 pp. U.S. $7.50.

The Larousse guide to spiders. 1983. By Dick Jones. Larousse, New York. 320 pp., illus. U.S. $11.95.

*__Lizard ecology: studies of a model organism.__ 1983. Edited by Raymond B. Huey, Eric R. Pianka, and Thomas W. Schoener. Harvard University Press, Cambridge. x + 502 pp., illus. U.S. $35.

Manual of methods in aquatic environmental research, part 1: analyses of metals and organochlorines in fish. 1982. By the Swedish International Development Authority. Fisheries Technical Paper No. 212. United Nations Food and Agriculture Organization, Unipub, New York. 33 pp. U.S. $7.50.

†**A new expanded guide to the birds of Alaska.** 1983. By Robert H. Armstrong. Alaska Northwest, Edmonds, Washington. 332 pp., illus. U.S. $16.95.

North American marsh birds. 1983. By Gary Low and William Mansell. Harper and Row, New York. 192 pp., illus. U.S. $44.95.

*__Owls of Europe.__ 1983. By Heimo Mikkola. Buteo, Vermillion, South Dakota. 397 pp., illus. U.S. $40.

Pack, band, and colony: the world of social animals. 1983. By Judith Kohl and Herbert Kohl. Farrar/Straus/Giroux, New York. 114 pp., illus. U.S. $11.95.

Photo reception and vision in invertebrates. 1984. Edited by M. A. Ali. Proceedings of a Symposium, University of Montreal, Lennoxville. Plenum, New York. 856 pp., U.S. $115.

*__Poisonous snakes.__ 1984. By Tony Phelps. Sterling (Canadian distributor Oak Tree Press, Toronto). *viii* + 237 pp., illus. $12.95.

†**Principles of wildlife management.** 1984. By James A. Bailey. Wiley, New York. *x* + 373 pp., illus. U.S. $26.95.

*__Redwings.__ 1984. By Robert Nero. Smithsonian Institute Press, Washington. 160 pp., illus. Cloth U.S. $22.50; paper U.S. $10.95.

*__The reptiles of British Columbia.__ 1984. By Patrick T. Gregory and R. Wayne Campbell. Handbook 44. British Columbia Provincial Museum, Victoria. *viii* + 102 pp., illus. $3.

†**The return of the sea-eagle.** 1984. By John A. Love. Cambridge University Press, New York. *xiii* + 227 pp., illus. U.S. $29.95.

Seals of the world. 1983. By Judith E. King. Second edi-

tion. British Museum of Natural History, London and Comstock. (Cornell University Press), Ithaca. 240 pp., illus. U.S. $24.50.

Sublittoral ecology: the ecology of the shallow sublittoral benthos. 1983. Edited by A. Scott Earll and D.G. Erwin. Clarendon (Oxford University Press), New York. *x* + 277 pp., illus. U.S. $35.

Synopsis of biological data on the grass carp. 1983. By F. A. O. Renouf, Montreal. 86 pp. $7.50.

Synopsis of biological data on the hawksbill turtle *Eretmochelys imbricata* (Linnaeus, 1766). 1983. By W. N. Witzell. Fisheries Synopsis No. 137. United Nations Food and Agriculture Organization, Unipub, New York. 78 pp. U.S. $7.50.

†**Under Alaskan seas: the shallow water marine invertebrates.** 1983. By Lou and Nancy Barr. Alaska Northwest, Anchorage. xiv + 208 pp., illus. U.S. $14.95.

Water quality criteria for European freshwater fish: report on chromium and freshwater fish. 1983. By the European Inland Fisheries Research Advisory Commission. EIFAC Technical Paper No. 43. United Nations Food and Agriculture Organization, Unipub, New York. 31 pp. U.S. $7.50.

Botany

Being a plant. 1983. By Laurence Pringle. Crowell, New York. 88 pp., illus. U.S. $10.95.

*__Canadian wildflowers 1985.__ 1984. By Mary Ferguson. Key Porter Books, Toronto. 112 pp., illus. $9.95.

Double flowers: a scientific study. 1983. By Joan Reynolds and John Tampion. Van Nostrand Reinhold, New York. 183 pp., illus. U.S. $22.50.

The ecology and physiology of the fungal mycelium. 1984. Edited by D. H. Jennings and A. D. M. Rayner. Cambridge University Press, New York. c400 pp., illus. U.S. $79.50.

Laboulbniales (Fungi, Ascomycetes). 1984. By Isabelle I. Tavares. Mycologia Memoir No. 9. Cramer, Braunschweig, Germany. c700 pp., illus. DM150.

†**Lob trees in the wilderness.** 1984. By Clifford and Isabel Ahlgren. University of Minnesota Press, Minneapolis. *xii* + 218 pp., illus. Cloth U.S. $29.50; paper U.S. $12.95.

Mate choice in plants: tactics, mechanisms, and consequences. 1983. By Mary F. Willson and Nancy Burley. Princeton University Press, Princeton. *xii* + 252 pp., illus. Cloth U.S. $35; paper U.S. $12.50.

†**Our green and living world: the wisdom to save it.** 1984. By Edward S. Ayensu, Vernon Lucas, and Robert De Filipps. Cambridge University Press, New York. c256 pp., illus. cU.S. $24.95.

Past and present vegetation of the far northwest of Canada. 1984. By J. C. Ritchie. University of Toronto Press, Toronto. 264 pp., illus. $35.

†**The rare vascular plants of New Brunswick.** 1983. By Harold R. Hinds. Syllogeus No. 50. National Museum of Natural Sciences, Ottawa. 38 pp. English, 41 pp. French + maps. Free.

†**The sunflower family (Asteraceae) of British Columbia, volume 1: Senecioneae.** 1982. By George W. Douglas. Occasional Papers Series No. 23. British Columbia Provincial Museum, Victoria. *x* + 180 pp., illus. $6.

†**Trilliums of Ontario.** 1984. By James S. Pringle. Third edition. Royal Botanical Gardens, Hamilton. 27 pp., illus.

†**Type specimens of bryophytes in the National Museum of Natural Sciences, National Museums of Canada.** 1984. Syllogeus No. 47, National Museum of Natural Sciences, Ottawa. 69 pp. Free.

*__Where have all the wildflowers gone: a region-by-region guide to threatened or endangered U.S. wildflowers.__ 1983. By Robert H. Mohlenbrock. Macmillan (Canadian distributor Collier Macmillan, Don Mills). *xiv* + 240 pp., illus. $22.95.

Environment

Acid rain information book. 1984. Edited by David V. Bubenick. Second edition. Noyes, Park Ridge, New Jersey. 397 pp. U.S. $39.

Air pollution: health and management. 1984. Edited by W. Klug, E. Runca, and M. J. Suess. Proceedings of a workshop, Laxenburg, Austria, July, 1982. Pergamon Press, New York. 176 pp. U.S. $47.50.

Amazonia. 1984. Edited by G. T. Prance and T. E. Lovejoy. Pergamon Press, New York. c300 pp. U.S. $31.

Antarctica. 1984. Edited by N. Bonner and D. Walton. Pergamon Press, New York. 350 pp., illus. U.S. $31.

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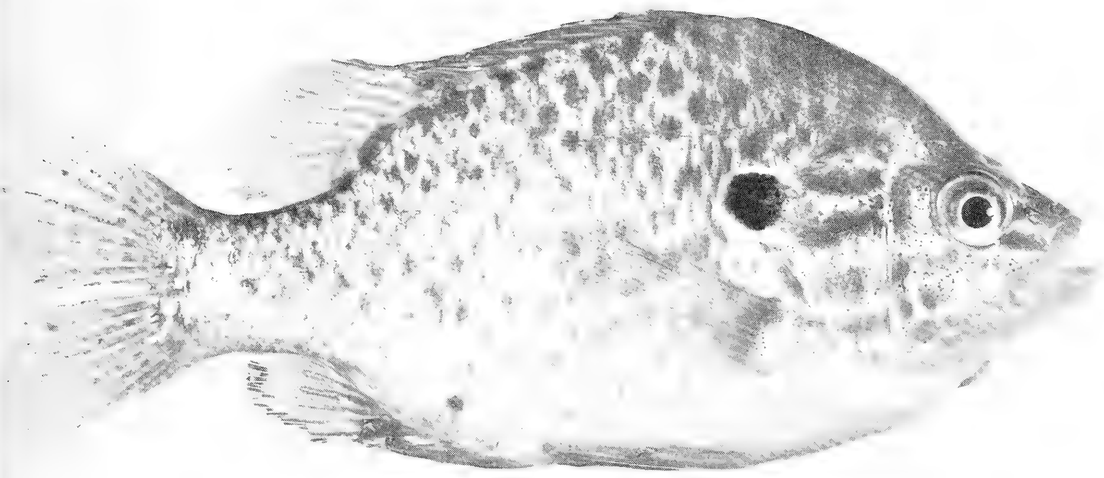

Volume 98, Number 4 October-December 1984

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FOUNDED IN 1879

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Her Excellency The Right Honourable Jeanne Sauvé, P.C., C.C., C.M.M., C.D., Governor General of Canada

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Back Numbers and Index

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Cover: Orangespotted Sunfish, *Lepomis humilis* from the Canard River, Essex County, Ontario. Photographed by Ian Craig. See note by Noltie and Beletz pages 494–496.

The Canadian Field-Naturalist

Volume 98, Number 4 October-December 1984

The Pre-settlement Breeding Distribution of Trumpeter, *Cygnus buccinator*, and Tundra Swans, *C. columbianus*, in Eastern Canada

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Lumsden, Harry G. 1984. The pre-settlement breeding distribution of Trumpeter, *Cygnus buccinator*, and Tundra swans, *C. columbianus*, in eastern Canada. Canadian Field-Naturalist 98(4): 415–424.

Explorers and fur traders reported swans present and sometimes abundant on the St. Lawrence, the Lake St. Clair area, and the Hudson Bay Lowlands of Manitoba, Ontario, and Quebec. Many of those records were probably of Trumpeter Swans (*Cygnus buccinator*), which have not bred in the east for more than a century. Their bones have been found in a number of archaeological sites, the easternmost being the Port au Choix site in Newfoundland. The second richest find of Trumpeter Swan bones in North America is at the Jesuit mission site at Ste. Marie-among-the-Hurons, Midland, Ontario. Tundra Swans (*Cygnus columbianus*) bred only north of the tree line. They were probably exterminated in the southern Hudson Bay region during the period of the fur trade, and recently have reoccupied parts of their range on the coasts of Manitoba, Ontario, and Quebec. Possibly Tundra Swans originally bred on Ungava Bay, and perhaps locally in Labrador. Trumpeter Swans disappeared from much of their range well before English-speaking settlers reached the plains. It is likely that Indians could not kill many swans with bows and arrows, but once they got firearms they reduced or exterminated Trumpeter Swans over wide areas. Trumpeter Swans may have bred to the east of the currently accepted limits of their range in areas with an ice-free period exceeding 145–150 d, and where calcium levels in the soils and food plants were high, particularly where glacial lakes and post-glacial seas had inundated the land, and where limestone forms the bedrock.

Key Words: Trumpeter Swans, *Cygnus buccinator*, Tundra Swans, *Cygnus columbianus*, archaeological sites, explorer reports, calcium requirements, medullary bone.

The easternmost known breeding of the Trumpeter Swan (*Cygnus buccinator*) in the United States was Saginaw Bay (see Figure 1 for location of places), Michigan (Banko 1960; Palmer 1976; Bellrose 1976). In Canada, Palmer included northern Ontario as far east as the south-west corner of James Bay, but omitted the Hudson Bay Lowlands north of Attawapiskat and the east shore of James Bay. Bellrose included the south-east corner of James Bay in Quebec, but omitted a narrow strip along the south shore of Hudson Bay. Those limits seem to have been based partly on Banko's map, but the latter suggested that the species bred to the east of the accepted boundary in Michigan and marked the limit in both Michigan and eastern Canada as hypothetical. Trumpeter Swans may have nested close to the Atlantic coast in the colony of Carolina. Banko quoted Lawson (1714) that "... when spring comes on they (Trumpeter Swans) go to the Lakes to breed", and commented that that account "... suggests the nesting of this species somewhere to the east ... of the breeding range of this species which was documented later." He continued "Lawson's specific use of the term "Lakes" is especially interesting, inasmuch as he does not hint of the breeding grounds of the Whistling Swan (*Cygnus columbianus*) ..., and Trumpeters are indeed wholly pond or lake breeders never known to nest along the banks of rivers". Lawson wrote well before English settlers crossed the Great Smoky and Allegheny Mountains, and at a time when no English-speaking traveller had recorded anything about the breeding habits of the Trumpeter Swan on the plains. As a surveyor he had travelled widely in the colony, and presumably either saw them nesting on lakes or was told that they did so by settlers or Indians (Rogers and Hammer, Tennessee Valley Authority, unpublished ms.).

We usually map the distribution of a species using specimens and reports of observers judged from their recorded work to be reliable. When a species such as the Trumpeter Swan in North America disappears from much of its range so early that no such record exists, we can infer its original distribution only from indirect evidence.

This paper deals with archeological and fur trader records of Trumpeter Swans and discusses the identity of the swans in explorer reports. It gives the current

breeding distribution of Tundra Swans in the Hudson Bay area and outlines possible former breeding distribution. It discusses the hypothesis that Trumpeter Swans bred east of the presently recognized range limits in areas with calcium-rich soils and summers with a long ice-free period. It further suggests that Trumpeter Swans were to a great extend invulnerable to Indians hunting with bows and arrows, but were an easy prey to those hunting with firearms.

Reports from Eastern Canada

The easternmost evidence of Trumpeter Swans in Canada comes from the Port aux Choix burial site in northern Newfoundland (50°41′N, 57°21′E) (P. A. Parmalee *in* Tuck 1976). That site, dated 2000+ BC, and located on the west side of the northern peninsula near the Strait of Belle Isle, contained 4 Trumpeter Swan bones, 22 from Tundra Swans, and 6 swan bones of undetermined species.

About 1600 km to the southwest lies the Coteau-du-Lac archaeological site in Soulanges County, Quebec, just upstream from Montreal (H. Savage University of Toronto, personal communication) identified two Trumpeter Swan bones from that site, which was occupied during the initial Woodland Indian period between 1000 BC and 1000 AD.

Early explorers in eastern Canada did not distinguish Trumpeter from Tundra Swans and it is not certain to which species they referred. Jacques Cartier (Biggar 1924) saw "many swans" on the St. Lawrence River downstream from Montreal between 19 and 28 September 1535.

Samuel de Champlain (Biggar 1929) also reported "an abundance of river fowl . . ." on the St. Lawrence and included swans in his list, but he did not give the date or place of his observation.

Reports from Southern Ontario

The earliest mention I have found of swans in southern Ontario is that of Champlain (Biggar 1929) who recorded ". . . a great quantity of game such as swans, white cranes, Canada geese . . ." on 28 October 1615 at what was probably Loughborough Lake near Kingston in eastern Ontario. Brother Gabriel Sagard (Wrong and Langton 1939) was a Recollet Missionary who lived with the Hurons in 1623 and 1624 near Midland, Ontario. After discussing the local abundance of ducks and game birds he wrote ". . . but for swans, which they call Horhey, are principally in the country in the Epicerinys." The latter were an Algonquin tribe now known as Nipissings who occupied the east shore of Georgian Bay in summer and lived very close and adjacent to the Hurons in winter (J. Hunter, Huronia Historical Parks, Midland, personal communication). That area includes Matchedash Bay, the Wye and Tiny Marshes, and the mouth of the Severn River where there were huge shallow bays and marshes. To this day excellent duck habitat exists there, and it probably provided good habitat for swans in the 17th century.

The Jesuit mission called Ste. Marie-among-the-Hurons was occupied from 1639 to 1649 (J. Hunter, personal communication). Sieur Gendron, a doctor of medicine, lived at that mission for some time, and wrote a letter dated 1644 describing the country of the Hurons (Shea 1868). He stated that "waterfowl are also abundant such as swans, cranes, tardes*, brenesches*, duck and teal." (Translation by E. Revel, Huronia Historical Resource Centre, Midland). Archeologists excavated that mission site and found 178 Trumpeter Swan and 105 Tundra Swan bones. (H. N. Nicol, University of Toronto. unpublished ms.).

Nicol's data suggest that the Trumpeter Swan contributed more meat than any other wildlife species. The bones found represented at least 60 birds, which yielded about 545 kg of meat. That compares to 337 kg from White-tailed deer (*Odocoileus virginianus*) and is exceeded only by the estimated 992 kg of beef raised at the Mission farm. Ste. Marie I appears to be the second richest archaeological site in Trumpeter Swan bones in North America, only the Cahokia site (375 bones) in Madison County, Illinois has more (Parmalee 1958).

Faunal remains have been listed for many other sites excavated in southern Ontario, but only two had Trumpeter Swan bones. One found at the Draper site (Durham County, east of Toronto, H. Savage, personal communication) had been worked and could have been a trade item brought in from a distance. The Grimsby site (Lincoln County, Niagara Peninsula) yielded 5 humeri and 1 ulna worked into tools and a wingtip (H. Savage, personal communication). All were burial goods in a Neutral Indian site dated from 1640 to 1650. It is possible that Indians scavenged those birds below Niagara Falls, as in recent years Tundra Swans have been found dead or crippled below the falls.

In 1679 Father Louis Hennepin (Thwaites 1903) entered the Detroit River with La Salle on 11 August, sailed through Lake St. Clair and continued to Lake Huron which he entered on 23 August. He described prairie-like country with elk, deer and bear, and mentioned "Turkey cocks and Swans are there also very common". Writing of the same area in 1701, M. de Lamothe de Cadillac (Lajeunesse 1960), commandant of the fort at Detroit, wrote "There are such large numbers of swans that the rushes among which they are massed might be taken for lilies." He arrived at

*Probably Canada Geese and Blue Geese.

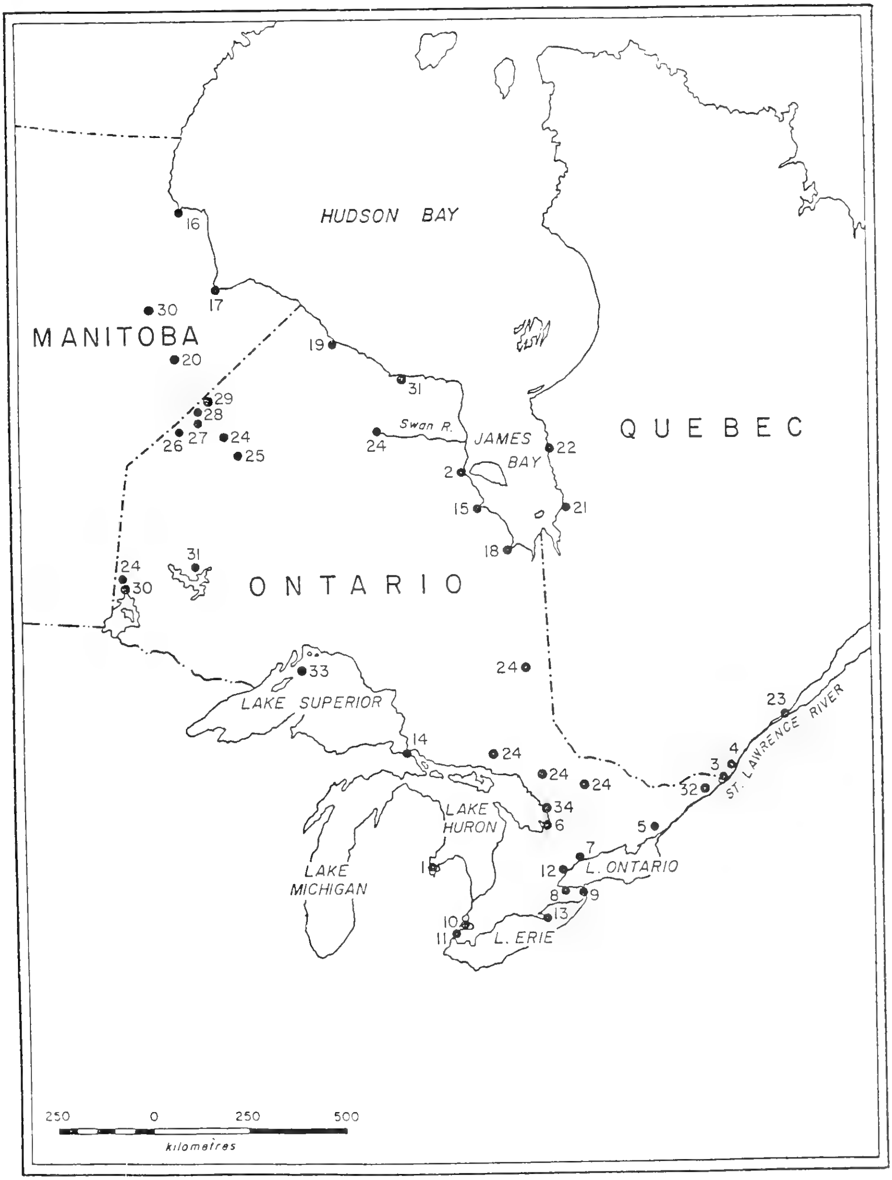

FIGURE 1. Locations mentioned in the text. 1. Saginaw Bay, Michigan, 2. Attawapiskat, 3. Coteau-du-lac, 4. Montreal, 5. Loughborough Lake, 6. Midland area, 7. Draper Site, 8. Grimsby Site, 9. Niagara Falls, 10. Lake St. Clair, 11. Detroit, 12. Toronto, 13. Long Point, 14. St. Mary's River, 15. Fort Albany, 16. Churchill, 17. York Factory, 18. Moose Factory, 19. Fort Severn, 20. Fox River, 21. Eastmain Fort, 22. Fort George, 23. Quebec City, 24. Swan Lake (7 locations), 25. Bearskin Lake, 26. Little Sachigo Lake, 27. Stull Lake, 28. Echoing Lake, 29. Ney Lake, 30. Cygnet Lake (2 locations), 31. Wapesi Lake (2 locations), 32. Swan Station, 33. Swan Rock, 34. Swan Point.

Detroit on 24 July 1701 and his letter was dated 8 October of the same year.

After Cadillac there were no reports of swans for over 150 years, likely because of the scarcity of aware settlers, preoccupation with survival on the frontier, a low literacy rate, and distraction caused by war and disturbances. In the second half of the 19th century, naturalists and academics began to study the native fauna and publish their results. They were just in time to record the last of the eastern migrant population of Trumpeters as it was disappearing. The records for southern Ontario summarized by Alison (1975) included:

6 specimens between 1857 and 1866 at Toronto;
2 specimens in 1878 and 1884 on Lake St. Clair;
Reports of 2 birds shot in 1860 on Lake St. Clair;
Reports of 3 birds between 1847 and 1886 at Long Point, Norfolk County

In addition, Barrows (1912) quoted a Major Boies that the Trumpeter Swan formerly occurred spring and fall on the St. Marys River near Sault Ste. Marie.

Reports from Northern Ontario

Trumpeter Swan bones were found (Baldwin 1967) in the Hudson's Bay Company site occupied about 1678–1720 at Fort Albany, Ontario (W. Kenyon, University of Toronto, personal communication). The earliest report of swans in James Bay is mention that, after a period of some privation, geese and swans were to be had at Moose Factory on 20 April 1674 (Tyrrell 1931). The first large flight of migrant Canada Geese (*Branta canadensis*) normally reaches James Bay about that date, although the vanguard of migrants comes 10–13 April (Raveling and Lumsden 1977). It is usually mid-May before Tundra Swans reach James Bay, the earliest recent record being 4 May (Lumsden 1975). Trumpeter Swans were notoriously early in their spring migrations (Hearne *in* Tyrrell 1934) and that 20 April record probably referred to Trumpeters. About 100 years later, in 1783–85, the swan flight into James Bay had almost disappeared; John Thomas recorded daily in his journals (Rich and Johnson 1954) the numbers and species of fish and game brought to Moose Fort, and he never mentioned swans. Banko (1960), however, quoted C. P. Wilson that 18 swan skins from the Moose River and Eastmain posts were sold in London in 1828. Those could have been from migrant Tundra Swans although Barnston's (1860) report (see below) suggests that Trumpeters were then still present in the area.

Most of our information on the fauna of northern Ontario in the 18th century comes from reports and specimens sent home by Hudson's Bay Company traders. The factors at the various posts were told to report on all the animals and plants that came to their notice.

James Isham served at Churchill and York Factory, Manitoba, between 1732 and 1761. His "observations" dated 1743 (Rich and Johnson 1949) contained this statement: "Swans we have great and small . . . seeing morning and evening some hundreds at a time in the water amongst the islands, but very shy, there is no killing them but as they fly by when setting in a stand . . . The old swans are but coarse food . . . but a young swan is reckoned tollerable good eating." He recognized both the Trumpeter and Tundra Swan and had eaten young swans (judging from internal evidence in his ms.) but it is not clear which species.

Andrew Graham served the Company from 1749 to 1791 at Churchill and York Factory, and at Fort Severn, Ontario. In his "observations" (*in* Williams and Glover 1969) he did not distinguish the Tundra from the Trumpeter Swan and his remarks seemed to refer mostly to the former. He stated that they were in no great numbers and bred along the coast, but added that "The lakes to the south abound with them." To the south of the trading posts at which he served are the huge muskegs of the Hudson Bay Lowlands with many lakes. It is very unlikely that Tundra Swans were in that forested muskeg habitat. From Isham's and Hearne's (see below) accounts I infer that the muskeg birds were Trumpeters.

Samuel Hearne's service started at Fort Churchill in 1766. In 1774 he was sent inland to build a trading post, and chose Cumberland House, Saskatchewan. While travelling there he killed molting swans on 5, 7 and 9 July (Tyrrell 1934). The locations were 3–7 days journey up the Fox River from its junction (56° 03′N, 93° 17′W) with the Bigstone River in the muskeg of northern Manitoba. His account of the Trumpeter Swan was more specific than any of this colleagues and clearly distinguished it from the Tundra Swan, thus (Hearne 1795): "There are two species of this bird that visit Hudson's Bay in summer; and only differ in size as the plumage of both are perfectly white, with black bill and legs. The smaller sort are more frequent near the sea-coast, but by no means plentiful . . . Both species usually breed on the islands which are in lakes; and the eggs of the larger species are so big that one of them is a sufficient meal for a moderate man without bread or any other addition . . . The flesh of both are excellent eating, and when roasted is equal in flavour to young heifer-beef, and the cygnets are very delicate".

Nearly 100 years later, Barnston (1860) reported, "Towards Eastmain Fort, in James's Bay, a considerable number of swans hatch; and a few are killed by the natives there, as they pass up and down narrow rivers communicating with the sea-coast and the lakes of the interior." Banko (1960) pointed out that, as Tundra Swans have never been found nesting as far south as 52° N, that is presumably a valid Trumpeter

Swan breeding record and the easternmost to come to his attention. I concur with that view.

Banko thought that the traffic in swan skins through the fur trade mostly involved the Trumpeter. However, it seems likely that the Tundra Swans along the southern and eastern coasts of Hudson Bay were similarly affected by hunting for trade. Most were probably gone by 1800, although Bell (1882) reported that they bred near Churchill and on the islands on the east side of Hudson Bay. Their recent appearance as a breeding bird in Manitoba (Pakulak and Littlefield 1969, Jehl and Smith 1970, Lumsden 1975), Ontario (Lumsden 1975) and Quebec (Heyland et al. 1970) should be seen as a return to a former breeding range after an absence of over 150 years.

Tundra Swans breed only north of the tree-line and have not been found nesting in forested muskeg. Figure 2 shows the recent brood and nest records of Tundra Swans in Manitoba, Ontario, and Quebec and also the northern limit of trees. Barnston's record of swans breeding near Eastmain is well within the forested Hudson Bay Lowlands, and is far from tundra habitats. It is in muskeg similar to Trumpeter Swan habitat.

Discussion

Names of places

When the name of an animal is given to a place it suggests that that animal was once found there. One must, however, be cautious about a Swan Lake, because it may have been so named for romantic reasons. There are four Swan Lakes listed in the Ontario Gazetteer (45° 30′N, 78° 43′W; 45° 58′N, 80° 07′W; 48° 25′N, 81° 45′W; and 48° 14′N, 80° 16′W). Three of those lie in a low calcium area (see below), and, if named for the birds, may have been stopping places for migrants. There are two Swan Lakes in the muskeg of northern Ontario. The first (53° 37′N, 83° 40′W), in the bed of the Tyrrell Sea, is drained by a river of the same name into James Bay. The second (54° 17′N, 91° 12′W) lies between the beds of lake Agassiz and the Tyrrell Sea among the lakes studied by Ryder (see below) which had high levels of calcium carbonate (see below and Figure 1). Those lakes may have been among the ones in which swans abounded (Andrew Graham *in* Williams and Glover 1969). The fur traders may have translated the Cree name for swan when they talked and wrote about those lakes.

That Cree name, Wapesi, was sometimes retained. There is a Wapesi Lake near the Hudson Bay coast (55° 12′N, 84° 48′W) where Tundra Swans still gather in spring and fall (K. Abraham, OMNR, pers. comm.). Far to the south, Trumpeter Swans may have used another Wapesi Lake, River, and Bay on Lac Seul. Those lie within the bed of glacial Lake Agassiz. Cygnet Lake (50° 00′N, 94° 53′W) adjacent to another Swan Lake (50° 20′N, 94° 55′W) in western Ontario, and a Cygnet Lake (56° 20′N, 94° 25′W) in the Limestone River drainage in northeastern Manitoba suggest that Trumpeter Swans may at one time have bred there. Swan Station (44° 58′N, 75° 42′W) in Grenville Co. is situated on Ordovician limestone in the bed of the St. Lawrence Sea. Swan Point (45° 10′N, 80° 08′W) and Swan Rock (48° 08′N, 89° 14′W) may have hosted migrants in the past.

I can find no places in Quebec for which the names Wapesi, Cygne, Swan, or Cygnet are applied. In New Brunswick there is a Swan Creek (45° 51′N, 66° 18′W) flowing through Permian bed-rock and lying within the ancient marine-submerged valley of the St. John River. In Newfoundland, Swan Island (49° 27′N, 55° 04′W) is located in the Bay of Exploits on Palaeozoic limestone. It seems possible that those locations acquired their names during the early years of settlement because of more than usual abundance of swans.

Identity of swans in early reports

Although the Tundra Swan is a straggler in eastern Canada today, it may have been more common in the 16th century and earlier. The presence of 22 bones in the Port aux Choix site in Newfoundland, where the swans were probably migrants, raises the possibility of an ancient breeding distribution extending to the rich, post-glacially submerged tundras of Ungava Bay. Single birds are sometimes seen there today (G. Cooch, Canadian Wildlife Service, personal communication) and they may nest there again. Perhaps there were even pockets of breeding birds in Labrador.

The early literature on swans in eastern North America is full of ambiguities on identity. However, the localities and particularly the dates of records often give a clue to the species involved.

Tundra Swans are late migrants in fall, remaining on the prairies until freeze-up, with most passing through Minnesota, Wisconsin, Michigan, and southern Ontario 5–15 November (Bellrose 1976). Judging from those migration dates, Cartier's birds on the St. Lawrence (19–28 September) were more likely Trumpeters.

Champlain's report of swans at Loughborough Lake on 28 October is closer to normal migration dates for Tundra Swans. As Quilliam (1973) reported Tundra Swans in the 20th century as early as 17 and 23 October in the Kingston area, we cannot be certain of the species to which Champlain referred.

The dates of Hennepin's (11–23 August) and Cadillac's (24 July — 8 October) reports showed that their birds were almost certainly Trumpeter Swans. Furthermore, Banko (1960) noted that Trumpeters had a very extended molt at Red Rock Lakes. Some males

might be flightless as late as October. L. N. Gillette (Hennepin County Park Reserve District, Rockford, Minnesota, personal communication) confirmed that for captive Trumpeter Swans; the flightless period for an individual lasted about 30 days; some subadults molted in late June, but others not until late September; breeding males were late, and some were still flightless in mid-October. Thus many of the swans seen by Hennepin may have been flightless or about to become so, and Cadillac's observations were made during most of the molt period for the species. Even Cartier may have seen some molters among the "many" swans on the St. Lawrence downstream from Montreal (19–28 September).

Molt migration does not seem to have been recorded for Trumpeter Swans (Hansen et al. 1971; Banko 1960). I think it likely that they move far enough from territorial pairs with broods to avoid being attacked and that numbers of molting Trumpeters in an area suggest that some are breeding.

Methods used to kill swans

The archaeological and explorer records of swans need further explanation. In southern Ontario Hennepin and Cadillac wrote that swans were common, and the large number of bones in the Jesuit Ste. Marie I site suggested that plenty of Trumpeter and Tundra Swans were available. However, there is a marked scarcity of Trumpeter Swan (2 sites in Ontario, 1 in Quebec, 1 in Newfoundland) and Tundra Swan (5 sites in Ontario, 1 in Newfoundland) bones in Indian sites occupied before 1700. That was during a period when Cartier and Champlain found swans over a very wide area.

The most likely explanation is that Indian hunters armed with bows and arrows found it difficult to kill many swans, whereas the Jesuits at Ste. Marie-among-the-Hurons had guns (Hunter, personal communication) which enabled them to kill game that Indians could not exploit. Sagard (Wrong and Langton 1939) wrote that the Hurons found it hard to kill large birds; "They kill some of the cranes and geese with their arrows, but they rarely get them, because unless these great birds have their wing's (sic) broken or are mortally wounded, they easily carry off the arrow in the wound and in time get healed." Trumpeter Swans, because they seldom left the marshes, were probably even harder to kill with bows and arrows than cranes and geese, especially at times when they were not nesting.

One might expect molting swans to be quite easy to kill. However, Hearne (1795) wrote . . . "In their moulting state they (swans) are not easily taken, as their large feet, with the assistance of their wings, enables them to run on the surface of the water as fast as an Indian canoe can be paddled, and therefore they are always obliged to be shot; for by diving and other manoeuvres (sic) they render it impossible to take them by hand." Unless the Indians could gather a hunting party with many canoes and carry out an organized drive of molting swans, they would have little success in killing them. Possibly the Trumpeter Swan bones in the Cahokia site were derived from such swan drives during the molting period.

After they acquired guns, Indians doubtless shot large birds for food, and they destroyed many skins of swans in the process. Hearne (1795) deplored the waste of both bear and swan skins which the Indians singed in preparation for eating, and wrote that ". . .; Otherwise thousands of their skins (swans) might be brought to market annually."

"Thousands . . . annually", taken for food, suggests a kill much larger than the number shot for trade. Hearne was familiar with only that part of the Trumpeter Swan's range that was within the trading area of the Hudson's Bay Company. To the south and west of that area, beyond his ken, others killed swans and in particular the settlers to the east on the wintering grounds of the Trumpeter undoubtedly shot all they could.

Former Trumpeter Swan Numbers

The Trumpeter Swan survived many years of slaughter before finally it all but disappeared from its range east of the Rockies. We might speculate on how many swans there were before the shooting began.

The Alaskan Trumpeter range supported an average of one swan/20 km^2 in 1968. Trumpeter Swans were spread over 4 million km^2 in their prairie and boreal range east of the Rockies; but suitable habitat probably covered only about 2.6 million km^2. If that range supported a density equal to that in Alaska, there may have been as many as 130 000 Trumpeter Swans east of the Rockies in the 1600s. The London records of the fur trade listed 108 000 swan skins sold from 1823 to 1877 (Banko and Mackay 1964) with an average of 3 000 per year between 1823 and 1853. In 1828, a high year in the trade, 5 072 Trumpeter and Tundra Swan skins were sold (Banko 1960). Five thousand Trumpeter Swans per year would not have been an excessive harvest with a population of 130 000. We must conclude that the trade in swan skins alone could not have been the chief cause of near extinction.

Hypothetical former breeding range

Climate — There are certain parts of Manitoba, Ontario, and Quebec from which breeding Trumpeter Swans would have been excluded for climatic reasons. Trumpeter Swans need an ice-free period of at least 140 and up to 154 days to complete their breeding cycle (Hansen et al. 1971). That isopleth (Figure 2) crosses northern Ontario about 110 to 130 km south

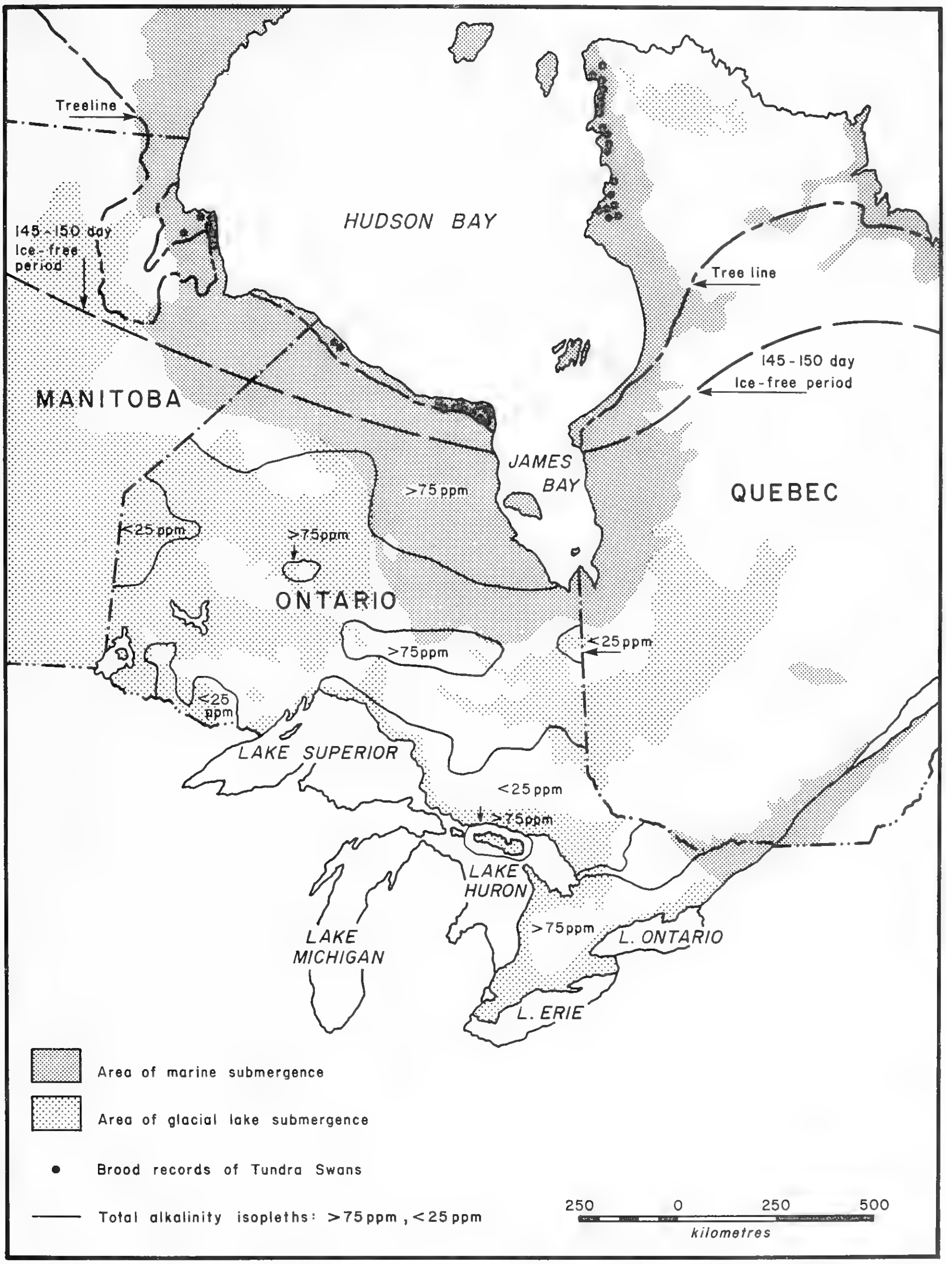

FIGURE 2. Marine- and glacial lake-submerged areas in Ontario and parts of Manitoba and Quebec. Also shown are Tundra Swan brood records, the tree line, the 145–150 day ice-free period boundary, and the > 75 ppm and < 25 ppm total alkalinity isopleths.

of the Hudson Bay coast, and angles west-north-west across northern Manitoba, Saskatchewan, and the Northwest Territories. In Quebec, the line crosses the James Bay coast close to Fort George (53° 45′N). I estimated its location in Ungava after Thomas (1953). We can, therefore, exclude the Hudson Bay coastal region from the hypothetical breeding range of the Trumpeter Swan. South of that line a large part of the Hudson Bay Lowlands in Manitoba, Ontario, and Quebec lies within an area in which we know or infer that Trumpeter Swans occurred.

The "little ice age" (1300–1800 AD) may have had some influence on the early distribution of Trumpeter Swans, but in Canada only the northern limit would have been affected. It is possible that the 140–154 d ice free isopleth was a little farther south than in Figure 2. The presence of Trumpeter Swan bones at Fort Albany in the 1600s suggests that the birds were not forced out of the southern part of the lowlands because of a reduced brood season.

Habitat — The breeding habitat of Trumpeter Swans in the Eastmain area of Quebec was likely the marsh and rich fen types described by Jeglum et al. (1974). Those types also occur throughout the Hudson Bay Lowlands of Ontario and Manitoba. Some of the indicator species of plants listed by Jeglum also are dominants in the communities occupied by Trumpeter Swans in Alaska (Hansen et al. 1971), for example, *Equisetum fluviatile, Carex aquatilis, Calamagrostis canadensis,* and *Carex rostrata.*

Because the mosaic of bog and fen in the Hudson Bay Lowlands between Eastmain and northern Manitoba is continuous without a break, I think it likely that the breeding distribution of Trumpeter Swans also was more or less continuous. It is improbable that an isolated stock bred on the east side of James Bay. The presence of bones in the Hudson's Bay Co. site at Fort Albany argues for the early presence of the birds there. Likely a scattered population of Trumpeter Swans bred from western Quebec across the muskegs to the area south of York Factory, Churchill, and beyond.

Calcium needs — The availability of calcium may govern the breeding distribution of herbivorous waterfowl such as swans and geese. No one has studied the calcium needs of swans, but something is known about the needs of geese. Calcium intake from food alone cannot supply enough for shell formation during egg laying (Hazelwood *in* Farner and King 1972), because of the remarkably high rate of shell deposition and the relatively low rate of absorption from food. When geese are building yolks they deposit medullary bone (Ankney and MacInnes 1978); Raveling et al. 1978) from intake of food and/or grit eaten on the nesting grounds (McLandress and Raveling 1981; Thomas 1983); that is drawn on during shell formation, provides the bulk of the material required by the shell gland, and is used up by the end of egg laying. Goslings also need a high calcium intake during rapid growth. Those considerations go far to explain why geese should seek out calcium-rich areas for breeding, and avoid those which are deficient.

In eastern and northern Canada both Canada and Lesser Snow Geese (*Chen caerulescens*) breed only in suitable habitats in calcium-rich areas and in lacustrine and coastal regions flooded as the glaciers retreated. Those areas are mapped in figure 2 after Prest et al. (1963).

Ryder (1964) measured the chemical characteristics of 310 large lakes in Ontario, and found that the highest alkalinity occurred in the Hudson Bay Lowlands and agricultural southern Ontario. Both areas have limestone bedrock. He also found high calcium carbonate levels in lakes situated in Precambrian country in the bed of former Lake Barlow-Ojibway and in the northeast lobe of glacial Lake Agassiz. I have included Ryder's $>$ 75 ppm and $<$ 25 ppm isopleths in Figure 2. Ryder cautioned that the exact location of his isopleths will depend on more intensive sampling. In general, the geese in the Hudson Bay Lowlands breed in an area of total alkalinity approaching and exceeding 75 ppm. The areas where geese have never bred have less than 25 ppm.

There are additional areas of high alkalinity on Precambrian rocks which were not flooded after the glaciers retreated, but where geese breed. One such area lies between the northeast lobe of glacial lake Agassiz in northwestern Ontario and the bed of the Tyrrell sea (Prest et al. 1963). Ryder (1964) found that 5 lakes in that area had high levels of total alkalinity. He listed Bearskin Lake, Little Sachigo Lake and Stull Lake with 80 ppm, Echoing Lake with 124 ppm, and Ney Lake with 88 ppm (Figure 1). Among them lies a Swan Lake from which no measurements of alkalinity have been taken.

In goose nesting areas and on those coasts of James and Hudson Bay where geese concentrate in large numbers in early spring, calcium is abundant in both soils (Protz 1982; Hanson and Jones 1976) and plants (Thomas and Prevett 1982; Jones and Hanson 1983). Plant food is, however, not generally available when the birds arrive because of snow cover. The geese gather in marshy areas between beach lines and grub in the mud for roots. I examined Snow Goose droppings on 19 May 1972 at such a site 20 km north of the Swan River mouth (53° 35′N, 82° 13′W). They were composed largely of mud. At la Pérouse Bay, 40 km east of Churchill just before egg laying, and after egg laying had begun, R. Jeffreys and students collected droppings which contained much silt, mud and root

fragments. The quantity of mud present suggested that its ingestion was more than accidental. The geese eat mud again in July when the goslings are growing fast (R. Jeffreys, University of Toronto, personal communication). The gizzards of geese are very acid (mean pH 3.86 in three Canada Geese. Lumsden, unpublished) and would have little trouble breaking down any calcium compounds into soluble form.

To satisfy calcium needs the goose strategy, at least in part, appears to consist of eating calcium-rich soil, and vegetation when available, building depots of medullary bone, then raiding those stores when needed to build egg shells. It seems likely that both Trumpeter and Tundra Swans have similar calcium requirements and adopt similar strategies. A captive female Trumpeter Swan died after laying two eggs at Kortright Waterfowl Park, Guelph. Sections from the femur, tibiotarsus, and tarsus revealed large depots of medullary bone. Whether Trumpeter Swans eat lime-rich mud to supplement their intake of calcium is not known.

Post-glacial flooding — It is significant that all but one of the explorer and fur trader reports of presumed Trumpeter Swans come from locations in post-glacially flooded areas on Palaeozoic limestones. The only exception is the Eastmain report by Barnston (1860). The Eastmain River flows over Gneiss and Schist formations derived from sedimentary rocks (Douglas 1969), and the lower third of the watershed was submerged beneath the Tyrrell Sea. Canada Geese nest in the Eastmain area which suggests that enough calcium is present to satisfy their needs.

Archaeological sites may help us to map early distributions, but as bones do not last long in acid soils we can expect to find gaps in the record. All the archeological sites mentioned in this paper lie on limestone rocks which were flooded when the glaciers retreated. Of particular interest is the Port au Choix site in Newfoundland, which, although having cool summers and a harsh wind-dominated climate (N. Patrick, Ontario Ministry of Natural Resources, personal communication), has an ice-free period long enough for Trumpeter Swans to complete their breeding cycle. Also, they might have wintered in that area. Gillespie and Roberts (unpublished ms, Canadian Wildlife Service, Ottawa) found Canada Geese and Black Ducks wintering at Parsons Pond (50°00′, 57°55′W) about 98 km south-west of Port au Choix. Trumpeter Swans could certainly survive anywhere where Canada Geese and Black Ducks are able to winter.

Conclusion

The potential Trumpeter Swan breeding range in eastern Canada was largely confined to post-glacially flooded land with high levels of calcium in the soil and Palaeozoic limestone bedrock. The northern limit would have been bounded by the 145–150 d ice-free isopleth. Such areas include parts of the Hudson Bay Lowlands in Manitoba, Ontario, and Quebec; most of southern Manitoba and western Ontario; parts of central Ontario and Quebec in the clay belts and where the topography permitted the formation of large marshes; extreme southern Ontario around the shores of the Great Lakes; the shores of the St. Lawrence at least as far as Quebec City; parts of Anticosti Island, and locally in New Brunswick, Nova Scotia, and Newfoundland.

It is likely that Trumpeter Swans could not have bred in a strip of country north of Lake Superior and Lake Huron as far as 49° N in Ontario; in Quebec the area which they could not occupy was probably more extensive and covered much of the central and eastern parts of the province. The Lac Saint Jean area may have been occupied. North of the tree line, also in post glacially submerged areas, the Tundra Swan probably bred, particularly around the shores of Ungava Bay and possibly in local areas in Labrador.

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The Biology of *Diapensia lapponica* in Newfoundland

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Diapensia lapponica, the only member of the Diapensiaceae in Canada, is a circumpolar, arctic-alpine, cushion plant. It is most abundant at the transition zone between sheltered snowbank habitat and windswept, snowfree habitat at locations where summers are cool with low productivity and on soils that are coarse, frost-disturbed, acidic, moist, and poor in nutrients and organic matter. Dead leaves, air-borne dust and sand, heat and moisture are trapped within the plant's domed growth form and this creates a more favourable microclimate for this stress-tolerant plant. Flowers are visited by several types of insect and seed is wind dispersed. A new August-flowering population is described from Newfoundland and Mount Washington, New Hampshire.

Key Words: *Diapensia lapponica*, arctic-alpine, cushion plant, soil characteristics, life history, phenology, seed biology, succession, plant diversity, soil polygon, stress-tolerant.

Diapensia lapponica L., common name Diapensia, has an unusual ecology and morphology and is the only member of the family Diapensiaceae native to Canada. Presently there is insufficient information to include the species in the Biological Flora of Canada Series. This initial contribution deals mostly with ecology, taxonomy, and distribution of southerly populations from eastern Newfoundland where field studies were conducted from 1976 to 1979.

Description of Mature Plant

Diapensia is a dwarf evergreen chamaephyte that exhibits a domed (Figure 1A) or spreading and mat-like growth form. The plant surface is a mass of interlocking rosettes composed of small leathery leaves. The superficial shell of living leaves covers the thin, frail branches that are embedded in duff (duff = the non-abscising dead and decaying leaves from previous years' growth). The branches, short main stem, and root system undergo secondary thickening. The tap and adventitious roots are generally shallow (< 30 cm) and convoluted since they grow in coarse, frost-disturbed soils. Petersen (1912) reported adventitious roots growing into the duff of the dome.

In proportion to total plant size *Diapensia* has many flowers, each about 1 cm in diameter (Figure 1B). The campanulate corolla has five stamens alternating with five corolla segments which are usually white or, in forma *rosea* (= var. *rosea*), tinged to varying degrees with pink. Petersen (1912) and Warming (1886) give many drawings of floral parts and Palser (1963) gives details of floral morphology from serial sections. A flower has three or four bracts subtending five sepals. The flower parts are thick and protect the developing sex organs and fruit from wind damage. The single trilocular ovary is positioned at the top of a peduncle which Ohwi (1965) reports to be 1-2 cm long. We have, however, observed that the peduncle elongates before and especially after first flowering and sometimes reaches 6 cm in length. The peduncle may or may not bear another bract. The taller peduncles raise the capsules into faster winds and above the snow surface where there is better dispersal of seeds. Capsules are usually disintegrated by late spring with only the grey and shredded peduncles remaining attached to the plant.

Plants can be aged by counting growth rings in stems and roots. Roots of *Diapensia* generally exhibit better defined annual growth rings than the stem (Petersen 1912). A more direct aging method described for *Dryas integrifolia* (Svoboda 1973, 1977) involves counting the persistent leaves, "*Dryas* shoots carry 5 green leaves on the average producing 2.5 new leaves per growing season. Leaves are active for two seasons" (Svoboda, 1977, p. 197). This technique can be used for *Diapensia* since Petersen (1912) reported that leaves are "functional for hardly more than two years". No doubt many large plants exceed a century in age.

The tiny brown seed (Figure 1E) is usually viable when plump and full of endosperm. It has a high fat content (Bliss 1962) and a reticulate surface patterning (Anderson 1961) with a testa two or three cell layers thick (Palser 1963). Seeds may appear nearly tetrahedral (Ohwi 1965) as a result of their mutual deformation during enlargement in the locules. More rounded seeds without distinct ridges may also be present. Petersen (1912) after Warming (1886) presents a drawing of an abnormally bloated pollen grain. Erdtman (1961) has unclear photographs which indicate perforations of the exine layer. Pollen from June- and August-flowering Newfoundland populations was studied under the SEM and light microscope and found to be of the same form (Figure 1F). The tricolpate and ovoid shape and the reticulate surface pattern are typical of many dicotyledons.

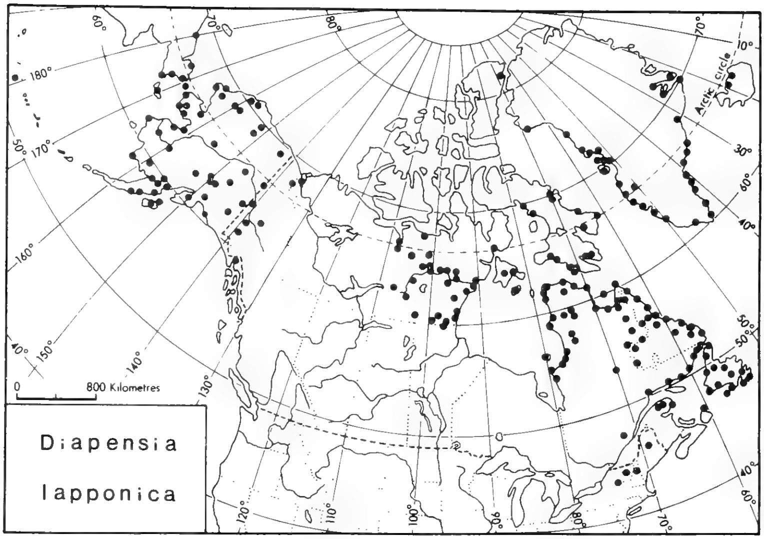

FIGURE 2. North American distribution of *Diapensia lapponica*, updated and adapted from Porsild (1957), Hultén (1958), Rousseau (1974) and Day and Scott (1981).

Diapensia has two subspecies: subsp. *obovata* with obovate leaves found in the Yukon, Alaska and Asia and subsp. *lapponica* with oblanceolate or spatulate leaves found in north-central and eastern North American and northern Europe (Hultén 1958). There seems to be a separation of the two within the Northwest Territories of Canada and perhaps also in north central Siberia (Busch 1926) but records are scarce for these regions.

Plants of subsp. *lapponica* from Sweden; Greenland; Mount Marcy, New York (Baldwin 1939); Mount Washington, New Hampshire (Love and Love 1966); and of subsp. *obovata* (Sugiura 1937) from Japan (?) have chromosome numbers of n = 6 or 2n = 12.

Distribution and Physical Habitat

The circumpolar distribution of *D. lapponica* (Figure 2) is well documented; Diels (1914), Busch (1926), Hultén (1958, 1971), Böcher (1938), Rousseau (1974), Damman (1976), Porsild (1957), Day (1978), and Day and Scott (1981). This plant occurs frequently in the Keewatin district of the Northwest Territories but is apparently absent between Bathurst Inlet and the east bank of the Mackenzie Delta. This disjunction may be related to the narrowing of the tundra in this region or to a slow dispersal of the western subspecies *obovata* and eastern subspecies *lapponica* from respective refugia. At present, this unexplained gap exists for the following additional species: *Veronica wormskioldii*, (Hultén 1958), *Luzula wahlenbergii*, L. *parviflora*, *Cardamine bellidifolia*, *Arctostaphylos alpina*, and *Braya humilis*, (Hultén 1964-71), but not for *Rhododendron lapponicum*, *Loiseleuria procumbens* or *Empetrum nigrum* which are commonly associated with *Diapensia*.

We believe the frequent and paradoxical occurrence of *D. lapponica* in coastal locations of southern Newfoundland is due to the foggy, pseudoarctic climate produced by the mixing of the ice-laden Labrador Current and Gulf Stream along the coastal rim near the Grand Banks. In parts of Newfoundland and northeastern North America which have a more continental climate with higher summer temperatures, the plants are found at higher altitudes such as Mount Washington, New Hampshire (44°17′N; 71°17′W), 1886 m; Mount Katahdin, Maine (45°52′N; 68°53′W), 1580 m; Mount Jacques-Cartier, Quebec (48°59′N; 65°57′W), 1248 m.

As with many arctic plants at the southern limit of their range, *Diapensia* grows in cool summer habitats (Dahl 1951; Damman 1976), usually where low nutrient and unstable soils (sometimes serpentine = high magnesium) create low-competition environments (Day and Scott 1981). Soil disruption is primarily the result of a loss of insulating snow cover by wind action (Tiffney 1972). Inland habitats typically have frost disturbed, low nutrient, acidic (Table 1), fast draining but moist orthic regosol soils (Table 2). *Diapensia* is

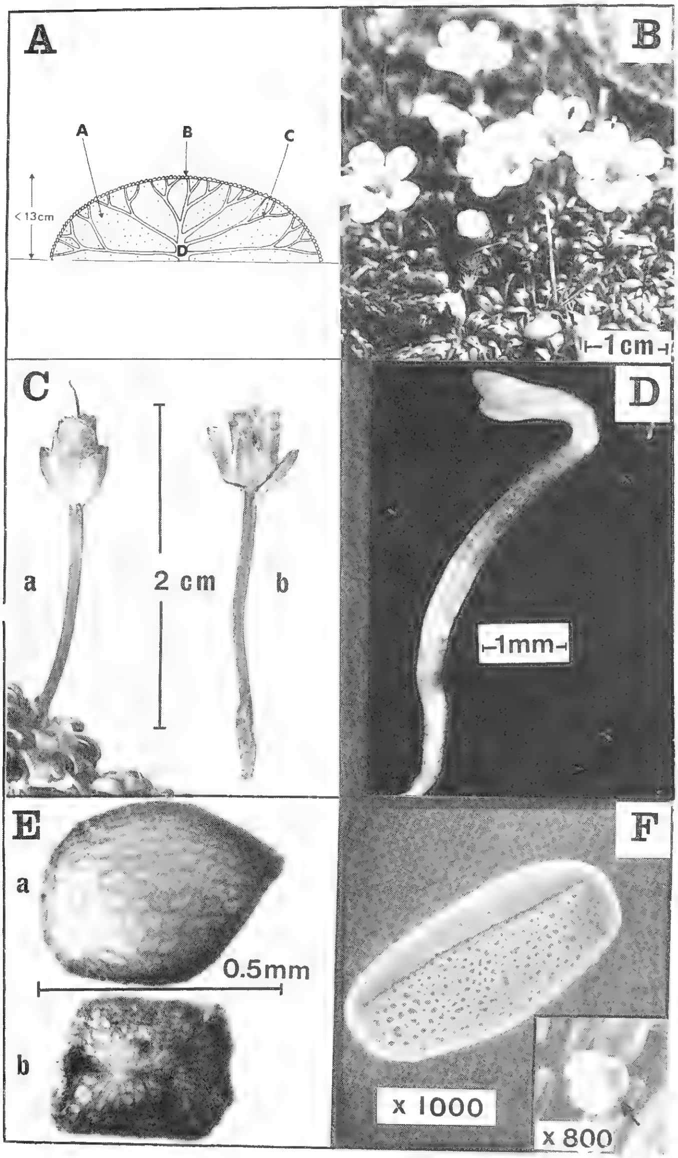

FIGURE 1. A = diagrammatic cross-section of a mature domed *Diapensia* plant, AA = dead and decaying leaves (duff), AB = living leaves, AC = thin branches, AD = main stem; B = flowers with diptera; Ca = young and Cb = mature fruit; D = seedling; Ea = viable seed and Eb = inviable seed, both showing a reticulate testa; F = pollen grains with end view.

TABLE 1. Compared nutrient profile of organic[+] and mineral soil at the Hawke Hills, S.E. Newfoundland.

Sampling Location	Soil Layer*	N	O-PO$_4$	K	Ca	Fe	Mg	Na	Cl	COD	volatiles %	pH
		Nutrients[1] μ/g		mg/g								
Diapensia dome, dead leaves and duff to 10 cm depth	L, H, Aeh	13.60	0.88	1.975	2.232	7.056	0.431	0.585	3.23	335	38.78	4.92
Surface, to 5 cm beneath *Empetrum eamesii*	L, H, Aeh	5.00	9.77	1.748	0.738	6.630	0.207	1.201	0.83	207	23.57	3.43
Soil polygon mineral soil to 8 cm depth	C	7.54	0.46	2.141	0.519	13.666	0.976	0.948	0.89	49	4.81	4.80

*National soil survey of Canada (1974) classification system.
[+]the organic soils are ~ 1/10-1/12 the density of the mineral soil.
[1]total K, Ca, Fe, Mg, Na analyzed with atomic absorption spectroscopy after HNO_3: HCl (4:1) digestion. Available nutrients determined for O-PO$_4$ by ascorbic acid/molybdate auto analysis, nitrate by UV absorption and chloride by Mohr titration (silver nitrate) (Rand et al 1975.)

common in climatically-exposed areas but is absent from high pH locations of basalt (Böcher 1938) or limestones (Fernald 1907). Low altitude coastal habitats in Newfoundland such as Cape St. Mary's (46°49′N; 54°12′W) and St. Shotts (46°38′N; 53°35′W) have closed dwarf shrub and herbaceous associations of low stature ($\leqslant$ 10 cm). The frequent fogs and manuring and deposition of shell fragments by sea birds improves the soil nutrient status in general.

Nutrient Recycling

Svoboda (1979) referred to the domed growth form of *Dryas integrifolia* as a "semiclosed microecosystem". This concept applies to *Diapensia* and can be supported by comparing the nutrient profile of the surface mineral soil with duff samples from beneath *Diapensia* and Pink Crowberry (*Empetrum eamesii*) (Table 1). Nitrogen, calcium, chlorine, and percentage volatiles are higher in the *Diapensia* duff while phosphorus is in low concentration. The *Diapensia* duff contains about eleven times less phosphorus than the sub-*Empetrum* sample and only about twice the amount of the mineral soil. This low amount of phosphorus in the *Diapensia* duff, when compared to the high value beneath *Empetrum*, suggests a more effi-

TABLE 2. Soil profile characteristics of the Hawke Hills orthic regosol of frost-disturbed sites.

Horizon*	Depth	Munsell colour (wet) Code	Munsell colour (wet) Description	Texture and description
C	8 cm	10YR3/2	very dark grayish brown	This coarse gravel has many large lichen-covered rocks and stones on the surface.
C	15 cm	10YR3/1.5	very dark gray-grayish brown	This gravel to loamy sand layer is loose, moist, with a few large rounded stones and easily shoveled.
Bfj-C	13.5 cm	10YR3/2.5	very dark grayish brown to dark brown	This sandy loam layer has more iron than the previous two and most organic matter. It is evolving toward a B horizon but is still somewhat frost disturbed.
Cx	+15 cm	10YR5/4	yellowish brown	This layer has a sandy loam texture. It is the parent material of a compact bouldery, stony, glacial till. It forms a weak fragipan, that is with some cementing and compacting.

*National Soil Survey of Canada (1974) classification system.

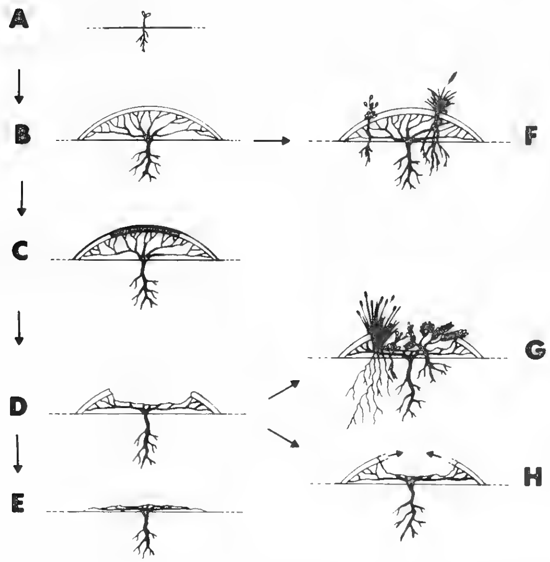

FIGURE 3. Life history of *Diapensia lapponica* A = germination, B = maturation, C = damage, D = degeneration, E = death, F and G = colonization by other species, permanent or temporary epiphytes. H = self repair by shoot proliferation after damage.

cient phosphorus reabsorbance from the dead and dying leaves.

Growth and Development

Figure 1D shows a newly germinated seedling with two fleshy cotyledons similar to the mature true leaves. The developmental life history of a *Diapensia* plant (Figure 3) was adapted from Griggs (1956) and Bliss (1963). In this figure, a seedling emerges (A) and grows to a dome-shaped plant (B). When surface shoots are killed, a critical point in the life cycle is reached (C). Winds eventually erode a hole in the dome (D) and degeneration may continue to death (E). The dome can be temporarily repaired by the proliferation of shoots surrounding the hole (H) or colonized by other species (G). The following vascular plants frequently grow on *Diapensia* domes in south-eastern Newfoundland: Three Toothed Cinquefoil (*Potentilla tridentata*), Mountain Cranberry (*Vaccinium vitis-idaea*), Northern Dwarf Blueberry (*V. boreale*), Common Hairgrass (*Deschampsia flexuosa*), and Alpine Bistort (*Polygonum viviparum*). These plants may permanently or temporarily root within the dome and (by definition) exhibit an epiphytic growth strategy (Day 1979).

Diapensia possesses characteristics typical of the "stress tolerant" plant strategy defined and discussed by Grime (1977, 1979). Growth is inherently slow and, as mentioned above, once nutrients are captured in leaf biomass they are released with delay after leaf death. In addition to trapping wind-blown nutrients, the dome traps solar heat. During 1977 the *Diapensia* microclimate at the Hawke Hills, Newfoundland was monitored using nine continuously recording thermocouples (Day 1978). On sunny spring days, the leaf surface temperature of a small *Diapensia* plant often exceeded that of any of the following locations in the neighbouring environment (also see Courtin 1968): air temperature at 10 cm, bare mineral soil at 2 and 5 cm depth, surface *Diapensia* duff, internal duff of *Diapensia* dome, leaf surface of *Empetrum* plus *Loiseleuria*, and 5 cm depth beneath *Empetrum* and *Loiseleuria*.

The difference in temperature with respect to the air temperature amounted to 4°C at 0800 and increased to 7°C to 8°C between 1300 and 1500 h. At 1900 h the surface of *Diapensia* had cooled off, equalling air temperature. The soil beneath these plants was often the warmest spot in the late evening (from 2000 h) to midnight.

Sponer (1964) points out that many alpine plants, such as *Silene acaulis*, lose their domed and compact growth form by internodal elongation when transplanted to lower elevations. Spomer concludes that

cool night temperatures are most influential in maintaining a compact growth form. In contrast to this, most transplants of *Diapensia* to warm habitats do not elongate and do not live beyond a few growing seasons. At lowland locations, the excess heating of the dome is considered a major factor limiting the distribution of the species (Day and Scott 1981).

Physiology and Phenology

Very little is known about the physiology of *Diapensia* other than a few light compensation and saturation points listed by Hadley and Bliss (1964). The phenology is better documented. Flowering throughout its range typically occurs in late May and early June. In southeastern Newfoundland the authors have found that *Diapensia* has two phenologically distinct population types. These populations exhibit consistent peak of blooming in either June or August. They can be distinguished morphologically only by the presence of flower buds and time of anthesis (Day and Scott 1981). June-blooming plants develop their flower buds by the end of the previous growing season. These buds overwinter and open from late May to early June. August blooming plants begin to develop flower buds in late spring. These begin opening in late July and flowering peaks in early August with a few scattered blooms rarely surviving until October (Figure 4). Late-produced flowers of the August population fail to produce viable seed. The two populations occur together and the proportions vary within habitats and between locations of southeastern and western Newfoundland and Mount Washington, New Hampshire (Day and Scott 1981). Preliminary observations suggest that plants with overwintering flower buds predominate in habitats with shorter growing seasons. We suspect that the late blooming population is not viable, and therefore absent, in habitats with short cool growing seasons because flowering would commence shortly before frost and snow. This aspect needs further study.

The live *Diapensia* leaves undergo annual changes in coloration (Day 1978). They are dark burgundy in winter and an olive green in summer, corresponding to the Munsel colour codes 5.0 R 3/4 and 2.5 GY 5/4 respectively (Figure 4). Svoboda and Bliss (1974) attributed similar leaf colour changes of *Dryas integrifolia* to chlorophyll destruction in overwintering leaves and its restoration in spring. The winter burgundy colour is due to anthocyanins remaining or accumulating in the leaf, probably genetically and environmentally controlled as for other plants (Nozzolillo 1978). The dark hue may enhance spring growth by absorbing greater amounts of solar energy. The red pigment itself probably acts as a sunscreen protecting the chloroplasts from high energy photon damage during and after the dormant period (Billings and Mooney 1968).

Levels of lipids, carbohydrate, and tannin in leaves and stems also fluctuate, with lipids and tannins very high in winter and spring and higher quantities of starch in early July (Petersen 1912). More recent work demonstrates that winter leaves have high protein levels, almost no starch, and more numerous vacuoles. These changes are associated with modifications in the shape of chloroplasts and mitochondria (Kallio et al. 1981; Kaaraski 1981). The scanty data suggest a seasonal accumulation and depletion of tannins and oils related to physiological adjustments as demonstrated by Mooney and Billings (1960) and Fonda and Bliss (1966) for carbohydrates in other arctic and alpine species. Bliss (1962) suggests that lipids, as high energy foods, are used by *Diapensia* in greater rates during early spring allowing rapid tissue regeneration, growth, and development at low temperatures. High respiration rates of *Diapensia* plants thawed in winter and kept at low temperatures are known (Wager 1941). Overwintering flower buds quickly finish developing in May and can flower even with intermittent snow cover (Howarth 1981).

The onset of winter dormancy is a gradual physiological process characterized by a cessation of flowering for the August bloomer and an intensifying burgundy leaf coloration. Cold hardiness of a fully dormant, mature plant approaches that of some seeds. Sakai and Otsuka (1970) have shown that *Diapensia* can survive immersion in liquid nitrogen (-196°C).

Flowers and Pollination

Our recent observations in Newfoundland confirm Petersen's (1912) report of Ostenfeld's unpublished Greenland notes that plants are slightly protogynous or homogamous. Often stigmas slightly protrude from unexpanded corollas, possibly facilitating allogamy (= cross pollination).

Diapensia flowers are visited by a number of hymenoptera and diptera (Figure 1B) insects (Petersen 1912). At the Hawke Hills, Newfoundland, Bumble Bees (*Bombus* sp., Apidae) were seen during all flowering periods observed (1975-77). On individual plants the flowers are close together and so these large bees can crawl from one bloom to the next. They often force their maxillae into unopened flowers to obtain the abundant nectar at the bases of the connate corollas. No floral scent is detected by humans. Solitary bees (*Andrena* sp., Andrenidae and an unidentified Halictidae) were caught while they visited flowers on 30 May 1976, at the Hawke Hills. They were not observed during August blooming. These tiny bees have their heads at the base of the corollas collecting nectar. They also collect the pollen which was seen in

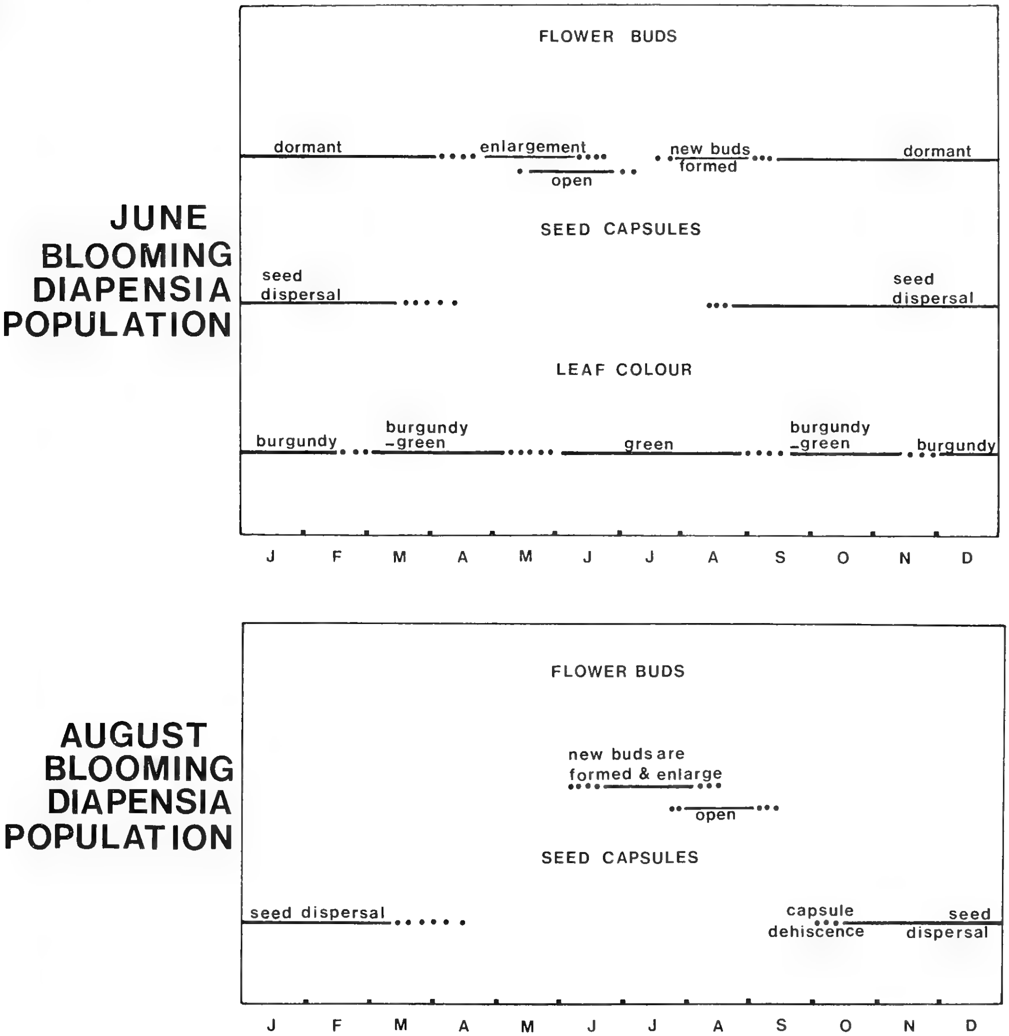

FIGURE 4. Phenological summary of S.E. Newfoundland *Diapensia lapponica* populations 1975–79.

masses on the tibial baskets of their legs. The Solitary Bees fly erratically in gusting winds while the larger Bumble Bees fly much straighter. Both types cruise close to the ground where the flowers are located, temperatures are higher, and wind speeds are reduced. Ants also feed on nectar but because of the absence of body hairs they do not collect pollen and are considered opportunistic, in relation to pollination, rather than mutualistic. The *Diapensia* flowers, on the Hawke Hills, with their unconcealed nectar and pollen, are sought out by many additional nonspecific insects as they provide the largest supply of these resources early in the growing season.

Seed Production

In 1976 the *Diapensia* of the Hawke Hills demonstrated a high reproductive output compared with associated species (Table 3). Of the eleven species sampled, *Diapensia* had the heaviest reproductive parts (= peduncle + bracts + calyx + capsule). *Diapensia* (ssp. *lapponica*) does not reproduce vegetatively by stem rooting to the extent of *Empetrum*, the other dominant species. It may have to expend more energy in seed production to maintain the population. Seed damage by a Pyrenomycete, *Apiotherium arcticum* (Connors 1967), although variable, is often quite high especially for capsules produced from the June bloom. This fungal disease was commonly observed on herbarium specimens of *Diapensia* from Europe and North America.

Diapensia has approximately eighty ovules per carpel (Palser 1963, p. 201) or an average of 240 per gynoecium which consists of three carpels. The actual seed production per capsule is far below this level. A random collection of 15 capsules collected on 11 October 1975 from the Hawke Hills had a mean of 73 ± 18 (95% C.I.; range of 27 to 128) apparently normal seeds/capsules. Exceptionally large plants may, in good year, produce as many as 50 capsules.

Capsules from the 1978 August bloom were collected 18 December at the Hawke Hills to test for seed viability. The seeds had undergone partial stratification (Nichols 1934) in the field. The material was kept frozen for 67 days, thawed, subjectively classified as viable or nonviable seed and then placed in petri plates between moist filter paper sheets under Cool White fluorescent lights at 20°C. Seed that was plump, not discoloured, and lacking fungal attachments was classed as viable, while nonviable seed was either shrunken, discoloured, or had fungal attachments. Germination was measured as emergence of a radicle from the testa. Of seed classed as viable, 59% had germinated by day 11 and all germination had occurred by day 21. The germination success was 73% for viable seed, 11% for nonviable seed and 51% the total germination, (Table 4). All newly germinated seeds were transplanted to soil (sand + peat = 1:1; pH $\simeq$ 6.4, P + trace elements added) but mortality was often high. By day 19, the cotyledons expanded. These germination percentages are much higher than the $\leqslant$ 4% obtained by Marchand and Roach (1980). Results indicate that the subjective assessment of viability is useful for selecting the best seeds for propagation. In addition, Kallio and Piiroinen (1959) report that gibberellin (concentration not given) will promote germination of this species.

TABLE 4. Germination of seed from August-blooming *Diapensia lapponica* plants, Hawke Hills.

Seed Type	Germination Number	%
Subjectively viable[1] seed n = 230	169	73
Subjectively nonviable[2] seed n = 132	14	11
Total n = 362	183	51

[1]viable seed = non-discoloured, non-parasitized, not shrunken.
[2]nonviable seed = discoloured or parasitized or shrunken.

A form of vegetative reproduction is now known for *Diapensia*. Alaskan herbarium specimens occasionally exhibit large cushions or primary domes with elongate stoloniferous shoots terminated by small, secondary domes (Figure 5). This type of reproductive offset has not yet been observed for herbarium or living material outside of the Alaska-Yukon area, and could reflect subspeciation in this glacial refuge area.

Plant Communities

Throughout its range, *Diapensia* is associated with a number of floristic elements in a surprisingly small array of habitat types. This information has been published elsewhere: Böcher 1938, 1949, 1952, 1954, 1963; Polunin 1948; Hanson 1953; Bliss 1963; Du Rietz 1965; Dervis-Sokolova 1966; Finin and Yurtsev 1966, Tikhomirov and Vavrilyuk 1966; Tikhomirov et al. 1966; Hadac 1972; Tiffney 1972; Meades 1973; and Day 1978. In southeastern Newfoundland at the Hawke Hills it is mingled with other arctic-alpine species, for example Alpine Azalea (*Loiseleuria procumbens*) and Alpine Bearberry (*Arctostaphylos alpina*), lowland forest floor species such as Bunchberry (*Cornus canadensis*) and Star-Flower (*Trientalis borealis*) (Table 3) and even with pastoral species like common Mouse-ear Chickweed (*Cerastium vulgatum*) and Yarrow (*Achillea millefolium*) at sheep-

TABLE 3. Plant Cover and reproductive productivity[1] within the *Diapensia* Community of Hawke Hills 1976[2].

Species ranked by % cover	1 m² Plots: 1	2	3	4	5	6	7	8	9	10	mean cover ± S.E.	total cover 10 plots	% of total vegetated area	mean productivity ± S.E.	no. of reproductive parts
	Plant cover (cm²)/Reproductive productivity (g dry wt)														
Empetrum eamesii[3]	1380/0.15	2516/0.98	34/-	1305/0.14	1741/0.08	957/-	476-	3895/-	931/0.03	2319/0.16	807 ± 1090	15554	39.2	0.150 ± 0.30	260 berries
E. nigrum[3]	-/-	-/-	-/-	-/0.03	-/-	-/-	-/-	-/-	-/-	-/-	—	—	—	0.003 ± 1.36	1 berry
Juniperus communis	-/-	2069/-	-/-	673/-	2248/-	-/-	601/-	-/-	-/-	2089/0.23	768 ± 978	7680	19.4	0.023 ± 0.073	6 berries
Diapensia lapponica	1154/0.30	47/0.11	-/-	160/0.15	840/0.39	36/0.02	709/1.49	532/0.12	4/-	361/0.27	384 ± 395	3843	9.7	0.290 ± 0.44	372 capsules* (+ peduncles)
Vaccinium uliginosum	28/-	69/-	310/-	143/-	511/-	36/-	226/-	363/-	375/-	1474/0.01	354 ± 426	3535	8.9	0.001 ± 0.003	1 berry
Potentilla tridentata	131/0.01	408/0.09	436/0.02	370/0.09	93/-	227/0.05	284/0.01	239/0.02	425/0.07	356/0.01	297 ± 122	2969	7.5	0.037 ± 0.035	75 seed heads
Rhacomitrium lanuginosum+	-/-	-/-	-/-	-/-	1227/-	-/-	-/-	-/-	-/-	240/-	147 ± 387	1467	3.7	—	—
Vaccinium boreale	142/-	92/-	-/-	358/0.05	-/-	171/0.07	111/-	96/-	216/-	124/-	132 ± 102	1310	3.3	0.012 ± 0.026	23 berries
Deschampsia flexuosa	143/0.01	53/0.01	94/-	110/0.03	156/-	176/-	40/0.01	88/-	102/0.02	48/0.01	101 ± 47	1010	2.6	0.009 ± 0.010	547 grains
Loiseleuria procumbens	-/-	51/-	-/-	-/-	378/-	-/-	37/-	179/0.27	-/-	126/-	77 ± 123	771	1.9	0.027 ± 0.085	94 capsules*
Vaccinium vitis-idaea	117/-	131/-	-/-	28/-	113/-	19/-	39/-	34/-	47/0.01	52/-	58 ± 46	580	1.5	0.001 ± 0.003	1 berry
Juncus trifidus	-/-	-/-	-/-	-/-	9/-	-/-	138/0.11	77/-	56/0.05	-/-	28 ± 47	280	0.7	0.016 ± 0.037	132 capsules*
Arctostaphylos alpina	-/-	-/-	-/-	-/-	234/-	-/-	-/-	-/-	-/-	-/-	23 ± 74	234	0.6	—	—
Maianthemum canadense	-/-	-/-	-/-	12/-	66/-	-/-	14/-	-/-	-/-	98/-	19 ± 35	190	0.5	—	—
Polytrichum commune+	4/-	-/-	-/-	28/-	20/-	30/-	18/-	-/-	-/-	14/-	11 ± 12	114	0.3	—	—
Trientalis borealis	6/-	-/-	-/-	-/-	9/-	-/-	-/-	6/-	-/-	42/-	6 ± 13	63	0.2	—	—
Prenanthes trifoliolata	-/-	-/-	-/-	-/-	-/-	3/-	-/-	-/-	20/-	16/-	4 ± 8	39	0.1	—	—
Calamagrostis pickeringii	-/-	-/-	-/-	-/-	24/-	-/-	-/-	-/-	-/-	-/-	2 ± 8	24	0.1	—	—
Solidago uliginosum	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	8/-	0.8 ± 2.5	8	< 0.1	—	—
Lycopodium selago	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	4/-	0.4 ± 1.3	4	< 0.1	—	—
Ledum groenlandicum	-/-	-/-	-/-	-/-	-/-	-/-	-/-	3/-	-/-	-/-	0.3 ± 0.1	3	< 0.1	—	—
Tetraplodon mnoides+	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	-/-	2/-	0.2 ± 0.6	2	< 0.1	—	—
Totals: Plant cover	3105	5436	874	3187	7669	1655	2693	5511	2176	7373 =	39679 = 39.7%, mean = 3968 ± 2379				
Bare ground	6895	4564	9126	6813	2331	8345	7307	4489	7824	2627 =	60321 = 60.3%, mean = 6032 ± 2379				
Productivity	0.47	1.19	0.02	0.35	0.47	0.14	1.62	0.41	0.18	0.69 =	5.54	mean = 0.55 ± 0.50			

[1]Vegetative reproduction and lichen cover not included.
[2]1976 was an exceptionally dry summer and several species had dry dead leaves.
[3]Cover of the two *Empetrum* species was lumped under *E. eamesii* because of vegetative similarity. *E. eamesii* was very much more prevalent.
+Mosses.
*Capsules had already dehisced, but for *Diapensia* this applies only to the June-blooming population.

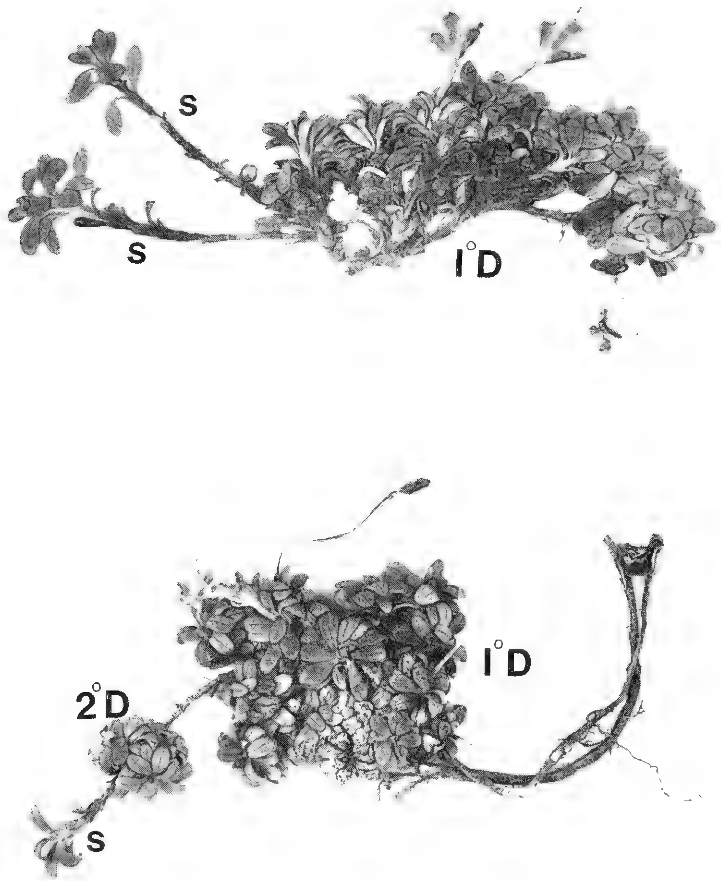

FIGURE 5. Alaskan herbarium specimen showing vegetative reproduction of *Diapensia lapponica* subsp. *obovata*. 1° D = primary dome, 2° D = secondary dome, S = short stolon.

grazed coastal locations like St. Shotts (53°35′ W; 46°40′ N).

The Hawke Hills *Diapensia* habitat was sampled with ten 1 m^2 plots placed randomly within locations where the plant was most abundant (Day 1978). There was approximately 40% plant cover and 60% rock and gravel, often covered by lichens (Table 3). The data illustrates a common trend in plant communities: dominance by a few species, *Empetrum eamesii, Juniperus communis* and *Diapensia* and the presence of many species which contribute very little to cover. Plots 5 and 10 from the edge of snow bank habitat had greater plant cover, note *Rhacomitrium*, while plots 1 and 3 are in more exposed locations where bare ground predominated. Reproductive productivity was extremely small during this record dry summer, however, in spite of this, *Diapensia* produced 372 capsules/10 square meters. Several plants were obviously stressed by drought. Above-ground parts of *Trientalis* and *Maianthemum* dried up late in August, many *Empetrum eamesii* berries dried before being shed and leaves of *Vaccinium uliginosum* were turning brown and drying. *V. uliginosum* seemed to be especially stressed. Only one berry was produced even though this species ranked fourth in percent cover. Drought stress in montane plant communities is not often recorded (Moore 1976).

Successional Role

With the exception of some coastal fog communities, *Diapensia* occupies extremely exposed arctic and alpine habitats where patchy vegetation among boulders and patterned ground is the rule. This is the appearance of the Rock Barrens within Meades' (1973) classification of southeastern Newfoundland heathlands. *Diapensia* is most abundant at the transition zone between the following two habitat extremes in southeastern Newfoundland (Day 1978):

1. the species-rich closed vegetation of the snow bank habitat in the slight topographic depressions, and
2. the species-poor patterned ground on the very exposed topographic convexities.

The vascular species diversity, expressed simply as species number within each habitat, is diagrammed (Figure 6). The transition from open ericaceous heathland (less exposed) to snowbank (topographic depression) to snowbank periphery to patterned ground (topographic convexities and exposed slopes) illustrates a rise and then fall in diversity.

The snowbank habitat is protected from the severe effects of wind and snow blasting for much of the winter and growing season. This probably accounts for the high species diversity in these depressions. The decreasing diversity from the snowbank periphery, to the patterned ground habitat can be explained by the

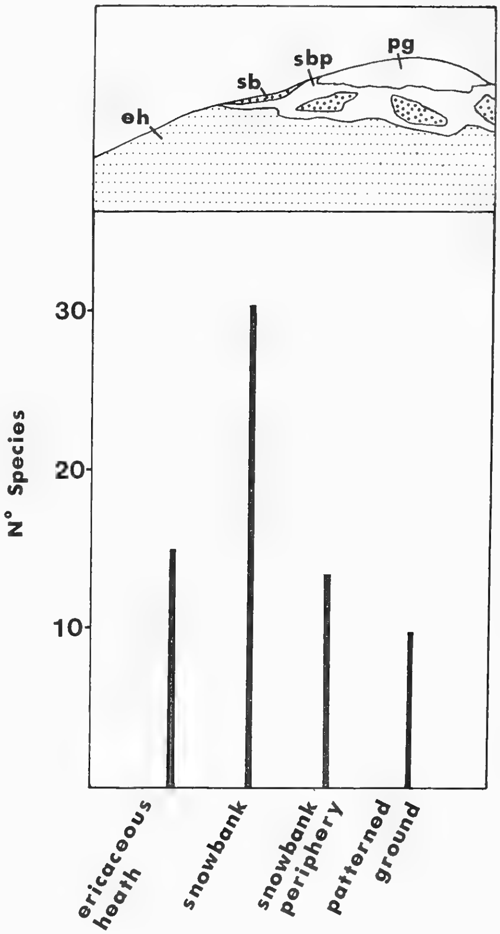

FIGURE 6. Rise and fall of diversity (# vascular species/habitat) along an exposure gradient: eh = ericaceous heath, sb = snow bank, sbp = snow bank periphery, pg = patterned ground.

increased wind exposure, loss of winter snow cover, and increased soil frost action. These factors add mounting stress (personal observations) to the vegetation of patterned ground on exposed hill tops and vascular plant diversity falls virtually to zero. Tiffney (1972) describes the same pattern from the White Mountains of New Hampshire. The low diversity of the ericaceous heath may be the result of previous fires and competition among the Ericaceae, especially *Kalmia angustifolia*.

A typical sorted polygon of the Hawke Hills region

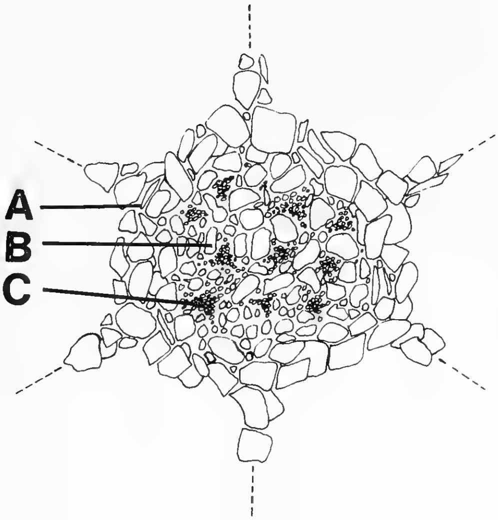

FIGURE 7. Diagrammed view of a soil polygon. A = stable peripheral zone of large clustered stones, B = polygon centre with large flattish stones on a gravel bed, C = *zeilenboden* marks: thrusting areas of fine, moist soil.

(Figure 7) is a unit that can be thought of as a replicated pattern extending in two dimensions across the landscape. Within individual polygons three microhabitats or zones can be recognized, each with a very different potential to be colonized:

A. The first is the periphery of large clustered stones that are often embedded in finer soil. The abundance of lichens on the surface of these rocks testifies to their relative stability. This is the zone where active polygons may be colonized at the periphery by *Diapensia* and *Potentilla tridentata* which spreads within the sheltered stone corridors.
B. The centre of the polygon is covered with flattish stones laying on the surface of finer material. These stones are also lichen-covered on their upper surface but considerable annual shifting occurs.
C. The areas of fine soil between the large flattish stones are known in the literature as *zeilenboden* (the German for line soil). These are the areas of most disturbance. Fine gravel, sand, and silt seem to be thrust up at these points in moist aggregation. Lichens do not grow here and there are no vascular plants. Water content remains fairly constant at 10% throughout the growing season but any seedlings here are soon thrust out of their rooting site by frost heave in winter. The microsites of ongoing frost churning within the *Diapensia* habitat are not colonized by outside "weed" species. Instead, these areas are slowly recolonized by the pool of original community inhabitants. Thus, this patterned ground exhibits "autosuccession" (Muller 1952) of soil polygons where there is no floristic change, just a shift in dominance. This is sharply contrasted with adjacent bulldozed locations which are characteristically occupied by a sparse flora of native plants and European weed species.

Snowbank communities build up greater amounts of organic and inorganic material (Warren-Wilson 1958; Oberbauer and Miller 1979) and these areas may eventually be colonized by dwarf phanerophytes, usually conifers, which make up the krumholz or tuckamoor within the ericaceous heath. Maximal *Diapensia* cover falls within an area between the environmental gradient from exposed patterned ground to sheltered snowbank. This is typical for many large cushion plants (Whitehead 1954). Plant community shifts along the exposure gradient are, in the long run, largely determined by climatic stability and major disturbances like fire, cutting of dwarfed conifers and grazing.

Interaction with Other Species

Fungi associated with the aboveground parts of *Diapensia* are listed by Conners (1967). Young roots have endotrophic and ectotrophic mycorrhiza (Hesselman 1900). The only known parasitic herbivore is the larvae of the Arctic Blue Butterfly (*Agriades aquilo*) which feed only on the flowers (Day and Jackson 1980).

Evolution and Migration

The family Diapensiaceae has two centres of diversity, northeastern North America and temperate eastern Asia. Members of the family are believed to be relicts of the Arctotertiary forest (or Nemoral Flora) of circumboreal distribution (Cain 1944). *D. lapponica* is presently the only circumpolar species as all other members of this genus, *D. himalaica, D. purpurea,* and *D. wardii* occur within the Tibet-China Himalayan region (Evans 1927; Scott and Day 1983).

Interglacial survival of an assemblage of boreal, coastal plain, and arctic species on coastal Newfoundland refugia is still a topic of speculation (Fernald 1911; Damman 1965; Terasmae 1973; Day 1978). Fairly recent work supports or gives evidence for coastal and western mountain refugia (Lindroth 1963; Drury 1969; Brooks 1977; Slatt 1977; Tucker 1979; Campbell 1980; Macpherson and Macpherson 1981). Slatt's sediment cores from southeastern Newfoundland indicate that the Grand Banks were exposed in the late Quaternary and formed an unglaciated land

mass larger than the province of New Brunswick. The duration of exposure before transgression by rising sea level is not yet known and no fossil peat deposits have yet been recovered from the Grand Banks (Day 1981).

Relationship to Man

Diapensia is not of economic importance as yet, however, the oils in its tissues (Bliss 1962) may some day be of value to man. The plant is one of the world's most beautiful and interesting arctic-alpine species with its showy flowers, persistant foliage and domed growth form. It is very desirable as a garden plant. Attempts at cultivation in lowland locations usually fail (Fries 1937; Blakelock 1952; Griffith 1964) but may succeed only very rarely when protected from the sun and planted in a moist, free draining soil (Dr. Uno Paim, Fredericton, New Brunswick personal communication).

Special Feature

With a streamlined heat- and nutrient-trapping growth form, *D. lapponica* represents extreme specialization for exposed arctic-alpine habitat. It grows in the most severely windswept habitat of Mount Washington, New Hampshire (Tiffney 1972) where a world wind speed record was logged at 374 km/h before the recording apparatus was destroyed. The dome, with the lowest surface to volume ratio of any geometric structure, is an ideal adaptation to such an environment. Presumably high winds with ice crystal and sand abrasion were some of the factors selecting for a low friction form. This growth form is not conducive to maximal photosynthesis which requires a larger surface area or at least a stratified leaf layer, here also absent. The drastic reduction of photosynthetic surface can be viewed as an evolutionary compromise in conjunction with physiological adaptation.

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Biogeography of Sympatric *Peromyscus* in Northern New York

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Kirkland, Gordon L., Jr., and Elizabeth A. Malinowski. 1984. Biogeography of sympatric *Peromyscus* in northern New York. Canadian Field-Naturalist 98(4): 440–443.

Mice of the genus *Peromyscus* were collected at 48 localities in Essex County, New York. *P. leucopus noveboracensis* and *P. maniculatus gracilis* were taken alone at 8 and 28 localities, respectively, while both species were captured at 12 localities. *P. leucopus* comprised 67.1% of 173 *Peromyscus* collected in the eastern tier of townships adjacent to Lake Champlain but only 1.6% of 577 *Peromyscus* taken in the more boreal communities of the western tier of townships. The altitudes of the localities at which these two species were taken separately and together differed significantly, and were as follows: *P. leucopus* ($\overline{X}$ = 94.9 m) both species together ($\overline{X}$ = 257.8 m), and *P. maniculatus* ($\overline{X}$ = 452.6 m). The intermediate altitudes at which the two *Peromyscus* were taken in syntopy coincide with the transition zone between the austral and boreal forests in Essex County. These sites were also characterized by greater tree species diversity than sites at which either species was taken alone.

Key Words: Deer Mouse, *Peromyscus maniculatus*, White-footed Mouse, *Peromyscus leucopus*, biogeography, sympatry, New York, altitudinal segregation, ecological distribution.

The White-footed Mouse, *Peromyscus leucopus noveboracensis* (Fischer), and the Woodland Deer Mouse, *Peromyscus maniculatus gracilis* (LeConte), are morphologically similar, primarily forest-dwelling mice whose geographic ranges overlap in the northeastern United States and southeastern Canada (Hall 1981). Because of morphological and ecological similarities of *P. l. noveboracensis* and *P. m. gracilis*, several investigators have endeavored to elucidate the mechanisms that permit these congeners to coexist. In studies of mixed populations of *P. l. noveboracensis* and *P. m. gracilis*, Klein (1960) and Smith and Speller (1970) observed slight differences in habitat preferences. Drickamer and Capone (1977) documented differential responses of these mice to four weather parameters, suggesting that niche separation might be behavioral/temporal as well as microspatial. Wolff et al. (1983) have proposed interspecific territoriality as the mechanism permitting the coexistence of *P. maniculatus* and *P. leucopus*. Because these studies focused on individual localities, they may not have detected biogeographic or ecological patterns of distribution that might be evident on a larger geographic scale.

A small mammal survey of Essex County, New York, which was carried out by field crews from the Vertebrate Museum, Shippensburg University, from 1971 through 1980, provided a data base of sufficient size and geographic extent to permit an analysis of the distribution and abundance of *P. l. noveboracensis* and *P. m gracilis* in an ecologically and physiographically diverse region (Malinowski 1981). Essex County, located in northeastern New York state, has a vertical relief of nearly 1.6 km, ranging from approximately 25 m along the shores of Lake Champlain on the eastern border to 1630 m on the summit of Mt. Marcy in the central High Peaks Region. Associated with this extensive vertical relief is a diversity of plant communities ranging from oak-dominated austral forests in the Champlain Valley to alpine tundra on the summits of the highest mountains. The small mammal survey was carried out so that at least one locality was sampled within each of the county's 18 townships and all major habitats within the county were represented. At each locality, the dominant and subordinate plant species were recorded, and these data were used in the analysis of the ecological distribution of *P. l. noveboracensis* and *P. m. gracilis*.

The two species of *Peromyscus* are not equally distributed in Essex County. *P. l. noveboracensis* comprised 67.1% of 173 *Peromyscus* trapped in the eastern tier of townships; 9.4% of 117 *Peromyscus* taken in the central townships; and only 1.6% of 577 *Peromyscus* collected in the western tier of townships (Figure 1). This decline in the abundance of *P. l. noveboracensis* from Lake Champlain westward in Essex County corresponds to the change from austral forests in the eastern lowlands to northern hardwoods and boreal conifer forests in western Essex County and supports Klein's (1960) determination that, on a microgeographic scale, *P. l. noveboracensis* is associated with oak dominated forests and *P. m. gracilis* with northern hardwoods habitats (see also Choate 1973). This relationship also is evident in the geographic ranges of these two mice; only *P. l. noveboracensis* occurs in the eastern deciduous forest to the south of the zone of sympatry, whereas only *P. m. gracilis* occurs in boreal forests to the north (Hall 1981). In Essex County, the presence of *P. m. gracilis* in the eastern lowlands and the virtual absence of *P. l. noveboracensis* in the west (Figure 1) is attributed to the presence of numerous remnant boreal habitats in the Champlain Valley (e.g. deep gorges, north-facing slopes, and bogs) and the absence of austral habitat in the western portions of the county.

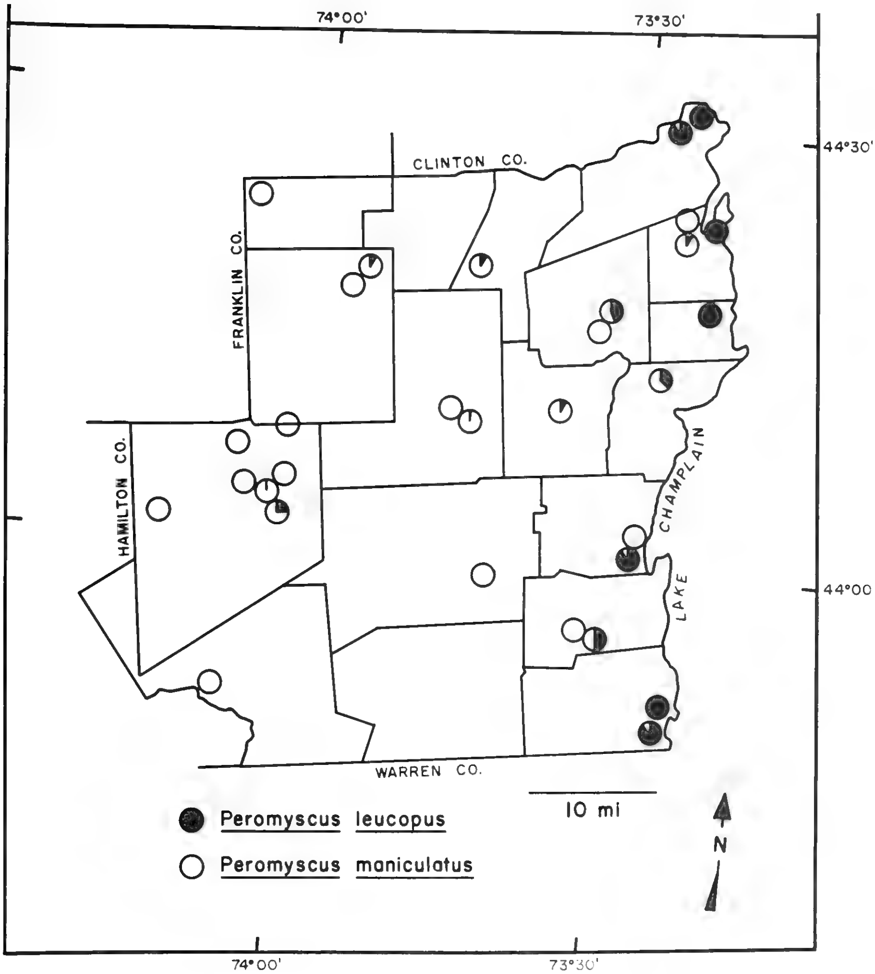

FIGURE 1. Capture localities for *P. l. noveboracensis* and *P. m. gracilis* in Essex County, New York. Pie diagrams represent proportions of the two species captured (black = *P. l. noveboracensis*; white = *P. m. gracilis*). In some instances, data from several adjacent localities have been combined into a single circle.

During the survey, *Peromyscus* were trapped at 48 localities in Essex County. *P. leucopus noveboracensis* and *P. maniculatus gracilis* were taken alone at 8 and 28 localities, respectively, while both species were captures at 12 localities. The altitudes of localities at which *P. l. noveboracensis* and *P. m. gracilis* were captured alone and together differed significantly (Kruskal-Wallis test, $p < 0.001$) in an ascending sequence from *P. l. noveboracensis* alone ($\bar{X}$ alt. = 94.9 m; median = 56.4 m) through both species together ($\bar{X}$ alt. = 257.8 m; median = 237.0 m) to *P. m. gracilis* alone ($\bar{X}$ alt. = 452.6 m; median = 466.5 m). These data suggest that, within Essex County, the two species of *Peromyscus* are segregated largely on the basis of altitude, and that they exist in syntopy principally at intermediate altitudes.

A similar pattern of altitudinal segregation has been observed between *P. l. noveboracensis* and the cloudland deer mouse, *Peromyscus maniculatus nubiterrae* Rhoads, at 22 localities in Tucker, Randolph, and Pocahontas counties, West Virginia (Kirkland, unpublished data). Both species were taken together at five localities ($\bar{X}$ alt. = 759 m, R = 567–840 m), whereas *P. m. nubiterrae* was taken alone at 17 localities ($\bar{X}$ alt. = 1081 m, R = 610–1340 m). The difference in mean altitudes is significant at $p < 0.05$ (Mann-Whitney U-test).

Prompted by the general observation made during the collection of specimens that both species tended to be captured together at sites supporting White Pine (*Pinus strobus*), we attempted to ascertain if any particular species of trees were typical of sites where the two species of *Peromyscus* were taken either alone or together. The analysis was based on ecological data recorded for each specimen, which included the species of trees (dbh > 7.6 cm) present at each sampling locality. Using this information, we made lists of the species of trees present at one-third or more of the sites where the two mice were taken either in allotopy or syntopy (Table 1). The results revealed little evidence of habitat segregation of the two mice on the basis of tree species. There was some indication of an austral-boreal segregation among conifers. *P. leucopus* was associated with White Pine both alone and with *P. m. gracilis*. Hemlock (*Tsuga canadensis*) characterized sites where *P. m. gracilis* was taken either alone or together with *P. l. noveboracensis*. Red Spruce (*Picea rubens*) was typical only at sites where *P. m. gracilis* was taken alone; in fact, it was never present at any locality at which *P. l. noveboracensis* was taken alone. There is no evidence of a preference by either species of *Peromyscus* for any of the eight species of deciduous trees, two of which (*Acer saccharum* and *Fagus grandifolia*) were typical of sites where both *Peromyscus* were taken alone as well as together.

What is striking about the three lists of tree species in Table 1 is the difference in number of tree species typical of sites where the two mice were taken alone versus together. Four species of trees (*Quercus rubra, Acer pensylvanicum, Populus* spp., and *Prunus serotina*), that were typical of sites at which both *Peromyscus* were trapped, were not typical of sites at which either mouse was taken alone (Table 1). Thus, nine species of trees were typical of sites at which the *Peromyscus* were taken in syntopy compared to only five species of trees at sites where either species was taken in allotopy. This suggests that the coexistence of *P. l. noveboracensis* and *P. m. gracilis* may be a function of greater tree species diversity; however, our data do not permit us to do more than note this

TABLE 1. Percent occurrence of trees present at one-third or more of the localities at which *Peromyscus* species were captured alone or together. If present at less than one-third of localities, percent occurrence is in parentheses.

	P. l. noveboracensis	Both species together	*P. m. gracilis*
CONIFEROUS TREES			
White Pine (*Pinus strobus*)	75.0%	83.3%	(28.6%)
Hemlock (*Tsuga canadensis*)	(12.5%)	58.3%	53.6%
Red Spruce (*Picea rubens*)	(0.0%)	(25.0%)	50.0%
DECIDUOUS TREES			
White Birch (*Betula papyrifera*)	75.0%	41.7%	(32.2%)
Yellow Birch (*B. lutea*)	37.5%	(25.0%)	64.3%
Red Oak (*Quercus rubra*)	(12.5%)	41.7%	(14.3%)
Sugar Maple (*Acer saccharum*)	62.5%	75.0%	75.0%
Striped Maple (*A. pensylvanicum*)	(12.5%)	41.7%	(28.6%)
Beech (*Fagus grandifolia*)	37.5%	33.3%	46.4%
Aspen (*Populus* spp.)	(12.5%)	50.0%	(3.6%)
Cherry (*Prunus serotina*)	(0.0%)	33.3%	(7.2%)
Number of species	5	9	5
Number of localities	8	12	28

relationship. The intermediate altitudes at which *P. l. noveboracensis* and *P. m. gracilis* were frequently taken in syntopy correspond to the transition zone between austral and boreal forests in Essex County, and are ecotonal areas characterized by greater tree species diversity.

In terms of its altitudinal, climatic, and ecological variation, Essex County, New York, largely mirrors the range of these factors found throughout New England. Based on the analysis of our data from Essex County, the biogeography of *P. l. noveboracensis* and *P. m. gracilis* in northern New York is consistent with Choate's (1973) observations on the distribution of these mice in New England, which were based entirely on his examination of museum specimens. Our results expand upon those of Choate by pointing out the relationship between tree species diversity and the coexistence of these two species.

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The Aquatic Macrophyte Vegetation of an Isolated Island Lake Adjacent to Lake Nipigon, Ontario: A Comparative Study after a Fifty-six Year Interval

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The 1982 appearance of an isolated lake far from human disturbance in North West Ontario, matched the 53-year old report of the distribution and abundance of many aquatic taxa. Readings of the physical and chemical factors were not significantly altered although it was clear that there had been a temporary rise in the water level due to a Beaver dam. The decrease in abundance of Yellow Water Lily, *Nuphar variegatum*, a narrow-leafed pondweed, *Potamogeton friesii*, and several marsh plants — Mare's Tail, *Hippuris vulgaris*, Cowslip, *Caltha palustris*, Water Arum, *Calla palustris*, and Marsh Cinquefoil, *Potentilla palustris* — was attributed to the raising of the water level. Plants known to be a food for Beavers decreased in abundance, those unpalatable increased. Since 1966, when the lake had returned to normal level, high reproductive capacity favoured increased abundance of Stonewort, *Chara globularis*, Quillwort, *Isoetes macrospora* and *I. echinospora*, Northern Watermilfoil, *Myriophyllum exalbescens*, and Watermarigold, *Megalodonta beckii*. The opportunistic species on bare aquasoil, Water Starwort, *Callitriche* sp., and Pipewort, *Eriocaulon septangulare*, flourished. The unbroken ring of aquatic vegetation of 1926 had declined in quantity. Differences between the flora of the small isolated lake (Teapot) and that of the large encompassing lake (Nipigon) are due to differences in the temperature of the water, alkalinity and wave action. The lack of suitable invading disseminules may have prevented the establishment in Teapot Lake of Red Pondweed, *Potamogeton alpinus*, Whitestem Pondweed, *Potamogeton praelongus*, and Flat-stemmed Pondweed, *Potamogeton zosteriformis*. The reasons for the absence of Slender Naiad, *Najas flexilis*, and Horned Pondweed, *Zannichellia palustris*, present in a bay a few kilometers to the west, remain unclear.

Key Words: aquatic plants, macrophyte, flora, freshwater lake, long-term changes, Beaver, *Castor canadensis*.

A unique opportunity allowed the authors to compare the present vegetation in an isolated island lake (Teapot Lake) with the records of the vegetation made 56 years ago. The lake is still rarely visited by humans so that the accuracy of predictions made following the studies in 1926 about the changes in vegetation with time can be assessed without taking into account the direct impact of man. In addition, a comparison is made between the vegetation in a small (0.33 km^2) island lake (Teapot) and in the larger (4480 km^2) encompassing lake, Nipigon (Figure 1).

In 1964 D. H. N. Spence assessed and photographed the macrophyte vegetation in several Scottish freshwater lochs and compared these with the description and photographs made in 1905 and 1910. The author attributed varying amounts of change over that fifty years to differing net rates of accumulation of mineral sediment (Spence 1964). There are few opportunities to make similar long-term comparisons in Canada. Some short-term studies have attributed obvious changes in vegetation to the modifications produced by man (Dale and Miller 1978; Miller and Dale 1979). The change of nutrient status of lake waters, the addition of toxic and other chemicals are frequently cited in North America as the operative factors producing changes (Volker and Smith 1965; Lind and Cottam 1969; Stuckey 1971). Recently the increase in abundance and distribution of *Sphagnum* moss between 1932 and 1979 in a susceptible lake has been attributed to change in pH perhaps caused by acid precipitation (Hendry and Vertucci 1980).

Teapot Lake (88°23′W, 49°37′N) lies on the southeast point of Shakespeare Island but only 50-100 m from Lake Nipigon on three sides (Figure 1). Half the lake is of a depth $>$ 10 m with a hypolimnion at the summer temperature $<$ 6°C and a definite thermocline. The lake is fed by intermittent run-off and by bottom feeding springs. It drains from a stream through Exit Bay to Lake Nipigon which lies about 3 m below the level of Teapot Lake (Cronk 1932; Hart 1932; Prichard 1935).

The original detailed study of the macrophyte vegetation was undertaken during the summer of 1926 concurrent with studies of the whitefish (*Coregonus clupeaformis*) population (Hart 1932) and studies of bottom fauna (Cronk 1932). These studies include descriptions of some features of the habitats of the animal population. The macrophyte study included identifying and plotting the distribution of species to a depth of approximately 2.5 m. Observations were

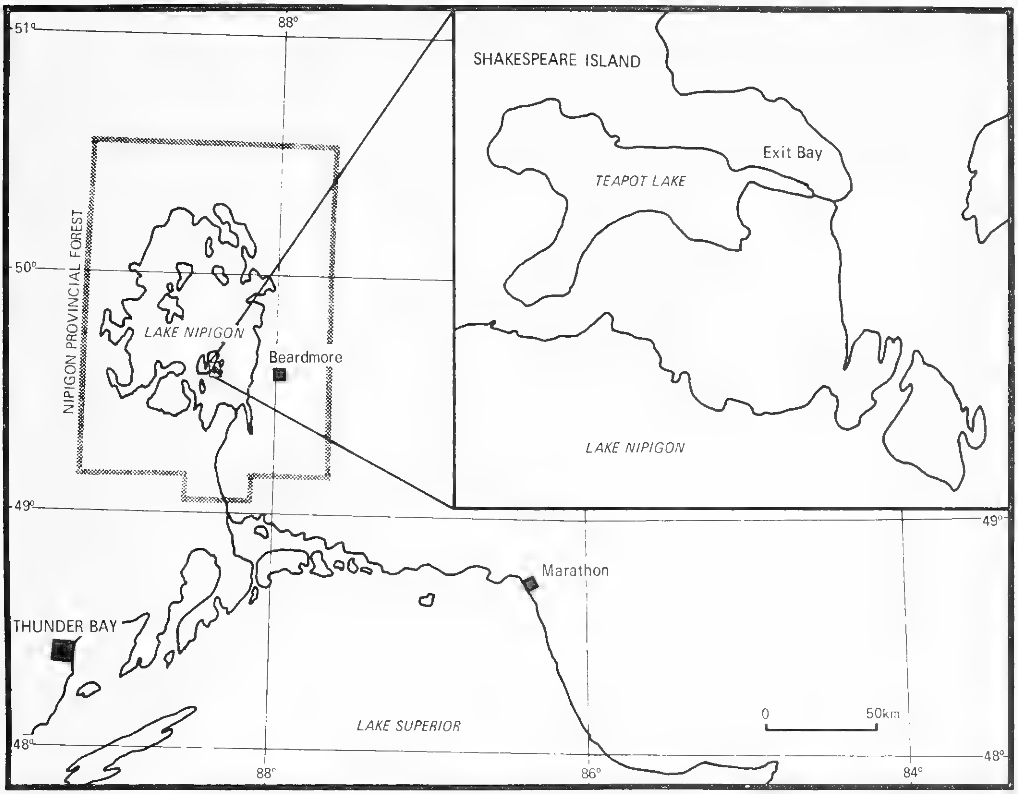

FIGURE 1. Map showing location of study area.

made from a rowboat or canoe anchored at 3 m intervals along the shore. Samples of each species were collected, pressed and mounted (Prichard 1935). Many specimens were examined in 1982 in the herbarium of the University of Toronto (TRT). The vegetation was described by a pair of maps on which the presence and abundance of ten taxa were presented. The maps were accompanied by written descriptions. Physical and chemical parameters including clarity of water, temperatures and depth of water, aquasoil character, wave exposure to prevailing winds, and pH were assessed in 1926 (Cronk 1932; Hart 1932). Some of these were thought to be operative factors in the distribution of groups of species in the heavily populated shallows ringing the lake. Prichard (1935) also predicted that succession would bring about changes with time such as the filling in with vegetation of Exit Bay where "the flora became so thick at midsummer as to be a hindrance to the progress of boats".

Methods

Teapot Lake was visited on four consecutive days, 25-28 July 1982. During the same period, the flora of the shallow water and strand of Lake Nipigon within 3 km of Teapot Lake were examined on Shakespeare Island and on the closest islands of the Macoun archipelago. One group (C.E.G. and L.S.) used a boat to collect specimens representative of the flora. These collections are in the herbaria of Lakehead University (LKHD) and University of Guelph (OAC). Positive identification of vegetative samples of aquatic vascular plants is now possible using keys developed for the genus *Myriophyllum, Potamogeton,* and other genera and species (Aiken 1981; Hellquist and Crow 1980; Ogden 1974; Voss 1967). Another group (H.M.D. and J.B.) circled the lake twice in a canoe to record comparisons of the vegetation present with the description given by Prichard and to record aquasoil types. Using the 1935 maps and descriptions, it was possible to

record the differences in vegetation. The taxa collected were rated for the lake as abundant, locally abundant, common, occasional and rare. Water samples, temperatures, secchi disc readings and extensive SNORKEL diving assisted in these comparisons. Alkalinity and pH were measured using a Hach Kit Model AL 36-B and conductivity with a Leslie-Metrix Minibridge, Model C-40.

Results

The description of the vegetation made in 1926 accurately fitted many areas of the lake in 1982 although the "unbroken ring" was not as dense. The aquatic vegetation was still confined to water less than eight feet in depth where scattered clumps of short (< 5 cms) Water Starwort (*Callitriche* sp.) plants occurred at this limit.

Little change in the distribution and abundance was obvious after the fifty-six years for the ten taxa identified in 1982 and matched to the name given in 1926, (Table 1). Table 2 lists 13 species less abundant than described by Prichard (1935).

Some taxa were identified only in 1982 (Table 3). Of these vegetative Water Starwort was the most abundant plant in deeper water. Vegetative Watermarigold (*Megalodonta beckii*) was common throughout the lake. Submersed vegetative rosettes of Arrowhead (*Sagittaria*) were locally abundant, forming mats in water 0.5 to 1.0 m deep.

TABLE 1. Taxa whose distribution and abundance similar in 1926 and 1982.

	Teapot Lake 1926	Teapot Lake 1982	Lake Nipigon 1982
Stonewort[a], *Chara globularis*	x	a	
Quillwort[a], *Isoëtes macrospora*	x	c	x
I. echinospora	x	c	x
Water Horsetail, *Equisetum fluviatile*	c	c*	
Floatingleaf Bur-Reed, *Sparganium angustifolium*	c	c	
Broad Ribbon-leaf[b], *Sparganium fluctuans*	c	c	
Largeleaf Pondweed, *Potamogeton amplifolius*	l	l	
Variable Pondweed, *Potamogeton gramineus*	c	c	x
Claspingleaf Pondweed, *Potamogeton richardsonii*	c	c	x
Northern Watermilfoil[c], *Myriophyllum exalbescens*	c	c*	x

Symbols are used as follows: [a]identified to genus only in 1926. [b]identified as Wild Celery (*Vallisneria spirilis*) in 1926. [c]identified as Green Watermilfoil (*M. verticillatum*) in 1926. x = present not rated for abundance, a = abundant, l = locally abundant, c = common, o = occasional, r = rare, superscript * vegetative only.

Physical and Chemical Factors

The surface water contained only a trace of dissolved CO_2 on August 5, 1924, and the pH 8.2. At lower depths, pH readings of 7.2 and 7.0 were found as well as measurable amounts of CO_2 (Table 4). The single subsurface water sample in 1982 gave a pH reading of 7.2 showing no clear difference.

Light transmission (Secchi disk readings) showed that the clarity of the water was not less in 1982 (Table 4). Light for aquatics at Teapot Lake is also influenced by the proximity of the cold water of Lake Nipigon. On 27 July 1982, a cold mist covered the Teapot Lake until noon, severely reducing incoming radiant energy for that day when there was no cloud cover. Surface water temperatures in the centre of the lake were 20.4°C on 5 August 1924, and 19.1°C on 19 August 1926. Comparable temperatures in 1982 were 19°C on 26 July and 20°C on 28 July. In the shallows of the south east, 24°C was recorded on 28 July 1982 similar to 23.7°C on 25 July 1926. The epilimnion for such a

TABLE 2. Taxa less abundant or not identified in 1982.

	Teapot Lake 1926	Teapot Lake 1982	Lake Nipigon 1982
Blue Flag, *Iris versicolor*	c	o*	
Common Arrowhead, *Sagittaria latifolia*	o	r	x
Creeping Spikerush, *Eleocharis palustris*	c	r	
Fries Pondweed[e], *Potamogeton friesii*	c	o*	x*
Sedge[f], *Carex rostrata*	c	r	
Sedge[g], *Carex stipata*	c	r	
Water Arum, *Calla palustris*	o	r	
Cowslip, *Caltha palustris*	l	r	
Mare's-tail, *Hippuris vulgaris*	l	r	x
Yellow Water Lily, *Nuphar variegatum*	a	c	
Marsh Cinquefoil, *Potentilla palustris*	o		
Bogbean, *Menyanthes trifoliata*	l		
Wild Celery, *Vallisneria spiralis*	c		

Symbols: [e]identified as Small Pondweed (*P. pusillus*) in 1926. [f] and [g] identified as *C. filiformis* and *C. vesicaria* respectively in 1926; other symbols as in Table 1.

TABLE 3. Taxa present in 1982 not on the 1926 list.

	Teapot Lake 1982	Lake Nipigon 1982
Needlerush, *Eleocharis acicularis*	r*	x*
Woolgrass Bulrush, *Scirpus cyperinus*	r	x
Rush, *Juncus nodosus*	r	x
Spearwort, *Ranunculus reptans*	r	x
White Waterbuttercup, *Ranunculus trichophyllum*	r*	x*
Water Parsnip, *Sium suave*	r	x
Loosestrife, *Lysimachia terrestris*	r	x
Water Starwort, *Callitriche*	a*	
Callitriche verna		x
Watermarigold, *Megalodonta beckii*	c*	
Pondweed, *Potamogeton spirillus*	o	
Common Cattail, *Typha latifolia*	o	
Arrowhead, rosettes, *Sagittaria* sp.	l	
Pipewort, *Eriocaulon septangulare*	l	
Water Mannagrass, *Glyceria striata*	r	
Greenfruit Bur-Reed, *Sparganium chlorocarpum*	r	
Mint, *Mentha arvensis*	r	
Scullcap, *Sculettaria epilobifolia*	r	
Tufted Loosestrife, *Lysimachia thyrsiflora*	r	

Symbols as in Table 1.

clear lake is shallow. In July and August, secchi disk readings varied from three to five m. (Cronk 1932). The measurements of temperature, pH and water clarity showed no clearly defined differences between 1924 and 1982. Hart (1932) described Teapot Lake: "Gently sloping sandy shores constitute about half the shoreline and the rest is divided between muddy or springy bottoms and more abrupt slopes strewn with large rocks." In 1982 fine sand or silty sand predominated on the S and SW shores. These were frequently underlain with clay. In addition, a flocculent layer of organic material floated on top of the sand along the W and SW shores in Exit Bay where the silt and organic matter were well covered by a mat of rosettes of Stonewort, Water Starwort and Quillwort.

TABLE 4. Physical and Chemical analyses of waters.

	Teapot Lake 1924[1]	Teapot Lake 1982[2]	Lake Nipigon 1980[3]
Temperature °C			
surface	20.4	20	17.0
bottom	6.4	—	6.6
pH			
surface	8.2	7.2	7.4
depth	7.0		7.4
Secchi disk m	3.7	4.5	4.5
Conductivity mho	—	38.6	110.0
Alkalinity mg l^{-1}	—	34.2	68.4

Data: 5 August[1] from Cronk (1932).
28 July[2]. 28 July[3], McIntyre Bay from Borecky, Rividan, and Damiani (1981).

Prichard (1935) noted that this area consisted of mud mixed with large quantities of organic debris.

One striking difference between the 1926 and 1982 surveys was the presence of large quantities of wood chips, small twigs and branches in the shallows of all shores, suggesting the death of some trees. Large accumulations were visible in relatively bare shore areas but not where there were abrupt slopes, boulders or large amounts of vegetation (as in Exit Bay).

The Strand Vegetation

The first study did not describe the strand or its vegetation except that "The soil thinly covers the diabasic rock which displays much evidence of glacial action and the island is rugged and well-wooded everywhere" (Cronk 1932). A forest inventory based on the 1962 aerial photographs lists Shakespeare Island as 50% conifer, 45% mixed and 5% water (Gollat 1975). Prichard (1935) noted that "over two-thirds of the shoreline is bordered by steep banks". In 1982 "high bluffs" and steep banks were less noticeable than a gradually sloping strand along the shore. The trees on the strand were only small saplings and seedlings. Sixteen annual rings were counted on one such typical tree trunk. Herbaceous perennials and short shrubs were the prominent life forms. We concluded that there had been a Beaver dam across the stream from Exit Bay raising the water level one meter, flooding the gently sloping shores for several meters from the present lake edge and killing the trees. The water had receded, however, at least 16 years prior to the 1982 visit.

Lake Nipigon Aquatic Macrophytes

The brief survey of the aquatics on SE Shakespeare Island and adjacent islands of Lake Nipigon found 16

plants in common with Teapot Lake and 23 unique to Teapot Lake (Tables 1-3). Fourteen were found only in Lake Nipigon waters. In the latter group were Red Pondweed (*Potamogeton alpinus*); Ribbonleaf Pondweed (*P. epihydrus*); Floating Brownleaf (*P. natans*); Sago Pondweed (*P. pectinatus*); Whitestem Pondweed (*P. praelongus*); Flat-stemmed Pondweed (*P. zosteriformis*); Horned Pondweed (*Zannichellia palustris*); Slender Naiad (*Najas flexilis*); Northern Arrowhead, (*Sagittaria cuneata*); Small Watermilfoil (*Myriophyllum alterniflorum*); Canadian Waterweed (*Elodea canadensis*); two St. John's Wort (*Hypericum ellipticum* and *Hypericum boreale*), and Bedstraw (*Galium trifidum*).

The action of the large waves of Lake Nipigon hampers the establishment of shallow water emergent macrophytes in all but the most sheltered areas. Several species were found in bays and sheltered pools and in the shelter of Mink Harbour, 3 km west of Teapot Lake. Here 15 species of submersed and floating leafed macrophytes were identified, several in flower or fruit. Most of this sheltered bay was less than 3 m deep with an organic substrate. The surface temperatures on July 28 varied from 12.5°C in a stream running in from the west to 15°C in the centre of the south part of the basin. These temperatures along the Lake Nipigon shores, even in the shallow pools, were 3 or 4 degrees less than in the centre of Teapot Lake.

Disturbances between 1924 and 1982

The lack of disturbance was one of the features that attracted the initial investigators to Teapot Lake (Hart 1932; Cronk 1932; Prichard 1935). The last major fire on Shakespeare Island occurred about 1885 (Gollat 1975). Some selective cutting took place on Shakespeare Island up to 1952. Stereo aerial photos taken in 1947 at a scale of 4″ to the mile show a log boom in Mink Harbour, a smaller one on the small island SE of Shakespeare Island and a tug boat with a boom in tow in Lake Nipigon immediately south of Teapot Lake. The pictures clearly show aquatic vegetation in the shallows of Teapot Lake but no sign of selective cutting of trees on the shores. The logs assembled in SE Shakespeare Island may not have been from the immediate area. In 1982 suggestions of tote roads, seen also on the 1962 photos, indicate that some larger timber trees were removed.

In 1962, a series of aerial photographs, unlike the previous series, showed no aquatic vegetation in Teapot Lake; the water level was higher and dead trees occurred in the water along the shallow shores. This series showed that a beaver dam was present at that time across the stream leading east out of Exit Bay. At the water edge the young trees were aged at 16 years by counting annual rings. This dates the recession of the water level and cessation of Beaver activity prior to 1966.

Seeds of starwort (*Callitriche*) collected in California germinated and grew successfully at 10°C producing both male and female flowers (McLaughlin 1974). In California, this is a plant of the early spring conditions found in vernal pools and streams that dry up in the summer. Other plants may require higher temperatures for successful growth. Studies show the depth limit of the bladderwort, *Utricularia purpurea*, in a New Hampshire lake is dependent on the length of the growing season determined by temperature. The threshold temperature for this plant is 16° (Moeller 1980), much higher than for Starwort.

In reviewing the zonation of plants in freshwater lakes, Spence (1981) stresses light and substrate as the chief factors influencing distribution. He does include, however, sets of diver-collected data from thermally stratified lakes where there is a shallow epilimnion. In these cases the downward penetration of angiosperms is confined by the base of the warm water zone as in Teapot Lake where Starwort was found.

Discussion

The aquatic vegetation was confined to a shallow depth in both 1926 and 1982. Secchi disk readings of 4.5 m in 1982 suggest that light has not been limiting. Water temperature below the shallow (3 m) epilimnion was so low as to prevent colonization between the scattered clumps of *Callitriche*.

The several species whose abundance and distribution in 1982 were similar to those described from the 1926 survey have either weathered the changes in the environment or they have returned to the previous distribution pattern. Recovery from disturbance may depend upon an abundance of plant propagules which can quickly become established on depopulated aquasoil. Those species which produce very large numbers of spores (of the order of 1000 per plant) include Stonewort and Quillwort. Northern Watermilfoil reproduces vegetatively from a large number of winter-buds. Similarly, a population of Watermarigold, using winter-buds, can quickly expand into new parts of a lake. It has been reported that, under some circumstances, the abundance of this species has increased following changes in water level (Robel 1962). In addition to this reproductive strategy there are other methods of survival. Water Horsetail, Large-leaf Pondweed, Variable Pondweed, Claspingleaf Pondweed, Floatingleaf Bur-Reed and Broad Ribbon-leaf, all have well-developed rhizomes. The energy stored in these organs allows the toleration of elevated water level and reduced light in the water column for a few years.

There are several species whose abundance was less.

In Exit Bay the remnants of the "large plots of the semi-aquatic buckbean, Bogbean (*Menyanthes trifoliata*) and the Mare's-tail (*Hippuris vulgaris*)" consisted of a few scrawny, depauperate plants of Mare's-tail close to the site of the former beaver dam. The traffic by Beavers and additions of mineral substrate used to plaster the dam may have had a local effect. The parts of a plant remaining *in situ* as the water level rose would receive less light energy because of the increased pathway and reduced clarity of the water. In addition, the water, made darker with suspended and dissolved coloured material, would induce an even shallower and warmer epilimnion (Dale and Gillespie 1977) and, as a consequence, the colder water of the hypolimnion would be even closer to the surface. The effect of Beaver (*Castor canadensis*) utilizing Yellow Water Lily as food may also have reduced the over-winter reserves and the subsequent number of leaves produced. In central Newfoundland (at a similar latitude to Teapot Lake) Yellow Water Lily was confined to water less than 1.8 m deep and was a major constituent of the summer diet of Beavers (Northcott 1971; 1972). The drop in abundance of Water Lily in Exit Bay, the site of the dam, was noticed particularly. The vegetation in Exit Bay in 1926 was described as being a hinderance to the progress of boats (Prichard 1935). No such restriction was evident in 1982. Species which have retained their position and abundance have not been identified as Beaver food, such as horsetails and pondweeds.

The species which inhabit marshy sites did not recover from the flooding. No successional changes had occurred through mineral soil build-up as found elsewhere by Spence (1964) or by the gradual filling in of Exit Bay by organic matter as predicted by Prichard (1935).

Wild Celery reported as prevalent in 1926 was not seen in 1982. The critical sheets from Prichard's collection are not extant in the Toronto (TRT) Herbarium. In Teapot Lake (1982) Broad Ribbon-leaf occupied areas where Wild Celery had been recorded. We believe this was a misidentification, Table 1. The report of Wild Celery (*Vallisneria*) from Teapot Lake (Prichard 1935) was used to establish the northern distribution boundary for this species in Canada (Scoggan 1978).

The two narrow-leafed pondweeds, *Potamogeton friesii* and *P. spirillus*, may have been called *P. pusillus* in the previous survey. Other small plants may have been overlooked, particularly if not flowering. There are three taxa, however, which should not have been overlooked in 1926 if they were abundant as in 1982 and must be considered as additions to the flora: Pipewort, Water Starwort, and Water Marigold. The seeds of the first two are small and may have been transported by ducks. The last named is conspicuous only when flowering above the water surface.

Differences between the aquatic flora of the Lake Nipigon shores of SE Shakespeare Island and Teapot Lake, may result from several environmental factors in addition to temperature. The alkalinity and conductivity are higher in Lake Nipigon waters indicating greater dissolved solids (Table 3). Hellquist (1980), Miller (1977), and Moyle (1945) have examined the distributions of several species and the range of alkalinity readings from water bodies in which the species is found. Swindale and Curtis (1957) also found characteristic groups of species in waters that they classified under four degrees of hardness. All these studies found that there was a limited range of dissolved solids within which each species was accommodated. The flora of Teapot Lake includes at least one species out of each of the four groups of water hardness (Swindale and Curtis 1957) and at least one species of pondweed, *Potamogeton*, from four of the six groups classified by clustering the *Potamogeton* taxa most commonly found at several alkalinity levels (Hellquist 1980). Of this method Hellquist states, however, "that plants in the field may often be found in habitats which seem completely alien to them but in which they seem to do quite well." The lowest range of tolerance of alkalinity for Fries Pondweed has been extended from 71.6 of Moyle (1945) to 42.7 in New England (Hellquist 1980) and to 34.2 in Teapot Lake. The pH of the water of Teapot Lake is also below the minimum of the water in which this species is found in Minnesota (Moyle 1945). The presence of Red Pondweed and Flat-stemmed Pondweed in the colder, more nutrient rich Lake Nipigon waters and their absence in Teapot Lake is difficult to explain. Both species were found elsewhere at lower alkalinity levels (Moyle 1945; Hellquist 1980). Their absence due to competition is unlikely when unoccupied space would have been available following the lowering of the water. It is more likely that large propagules failed to make the journey from the nearby source. The absence of Sago Pondweed, the single species in Group VI of Hellquist (1980), can be explained, however, by the alkalinity. Teapot Lake is slightly below the published minimum level.

The correlation of the differing substrates or aquasoil types in various parts of Teapot Lake with occurrence of species was not as clear in 1982 as in the 1926 study (Prichard 1935). The capability of opportunistic species to occupy bare areas may explain the abundance of Water Starwort at the greatest depth of vegetation and the appearance of Pipewort, Cattail, and Spearwort in the inorganic aquasoils of the recently exposed shores. Other correlations with organic or inorganic aquasoils are difficult to separate

from wave action, water movements, etc., as suggested (Prichard 1935).

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Activity of American White Pelicans, *Pelecanus erythrorhynchos,* at a Traditional Foraging Area in Manitoba

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O'Malley, J. Brian E., and Roger M. Evans. 1984. Activity of American White Pelicans, *Pelecanus erythrorhynchos,* at a traditional foraging area in Manitoba. Canadian Field-Naturalist 98(4): 451–457.

We studied flocking and foraging activity of American White Pelicans (*Pelecanus erythrorhynchos*) at Grand Rapids, Manitoba. Arriving and departing pelicans used both soaring and flap-gliding flight. Arriving birds selectively joined larger-than-average loafing or foraging groups, which may facilitate food finding. Arriving flocks often split into smaller groups which landed separately around the study area or continued to other foraging sites. It is thus unlikely that flocking functions to maintain groups from the breeding colony to foraging sites. Departures to the breeding colony originated mainly among birds on loafing bars, and were strongly clumped. Birds leaving the foraging area behaved similarly to pelicans departing a colony en route to a foraging site, which argues against colonies serving as information centers. The behavior of pelicans moving between foraging sites distinguished them from arriving and departing commuters. Maximum foraging activity occurred at night, correlating with activity of some prey fish, and permitting travel during the day when thermals and formation flocking can be used to reduce flight costs.

Key Words: American White Pelican, *Pelecanus erythrorhynchos,* flocks, foraging, local enhancement.

Previously we showed that American White Pelicans, *Pelecanus erythrorhynchos,* (hereafter referred to as White Pelicans) follow each other and form flocks when they leave their breeding colony on foraging trips (O'Malley and Evans 1982a). We concluded that flocking permits effective use of local enhancement as a means of locating thermals, which can reduce travel costs, as can adoption of specific flock formations (O'Malley and Evans 1982b). We also speculated that flock travel could facilitate group foraging, which is common in White Pelicans (Cottam et al. 1939; Behle 1958; O'Malley and Evans 1983), by ensuring that individuals don't disperse and lose the benefits of group foraging (e.g. Rand 1954). Observations of flocking behavior at a foraging site are thus crucial to the interpretation of the adaptive value of flocking in pelicans.

Although the diet of White Pelicans has been studied over much of the species' breeding range (Ferry 1910; Alcorn 1943; Behle 1944, 1958; Anderson et al. 1969; Lingle and Sloan 1980), there have been no extended studies of any aspect of White Pelican foraging behavior. We studied flocking and foraging behavior of White Pelicans at a traditional foraging site. The objectives were to determine whether flock travel from a colony to a foraging site aids in the establishment of foraging flocks, to describe the process of flock formation for the return trip to the colony, and to describe the timing of those activities in relation to foraging.

Study Area and Methods

The pelicans we studied breed at Kawinaw Lake, Manitoba (52°50′N, 99°29′W). They disperse in a wide arc north and east of Kawinaw Lake to forage, the majority travelling toward Lake Winnipeg. We studied them 40 km north of the colony, at the Grand Rapids hydroelectric dam on the Saskatchewan River near its mouth at Lake Winnipeg. We observed activities between 0430 and 2230 CDT, the daylight hours, from 21 May to 24 June 1981, for a total of 120 h. Observations were made from an elevated point (Figure 1, A) using binoculars and a 25–45X spotting scope. The numbers of pelicans foraging and loafing within the study area were recorded every 30 min during each observation period. The close packing of birds on the gravel bars used for loafing (Figure 1) often made necessary estimates of numbers rather than actual counts, but the estimates usually agreed with subsequent counts within 5%. The occurrence of foraging, and the behavior of arriving and departing pelicans, were noted throughout each observation period.

Qualitative observations were made one night from 2230 to 0430, and activity at the mouth of the river and on Cross Lake above the dam was also observed for short (<3 h) periods on several occasions. Those observations were made to determine whether foraging behavior near the dam was representative of "normal" activity and to monitor movements between foraging sites.

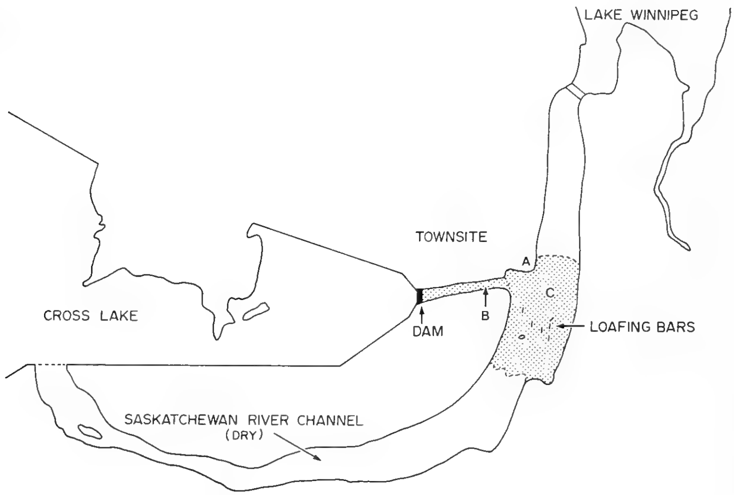

FIGURE 1. A map of the Grand Rapids study site. The shaded area indicates the main foraging area observed from point A. Area B is the man-made tailrace channel, and C is the terminal portion of the original channel bordered upstream by dry riverbed.

Flock sizes and foraging activities could be affected by the numbers of pelicans travelling between the colony and foraging sites. The number commuting each day increases greatly during the breeding season as nest attendance patterns change (O'Malley and Evans 1982a). Most of our observations were made during a period when the number of commuting adults should have remained relatively stable.

Single birds were included as "flocks" for purposes of descriptive statistics and tests. They usually comprise a significant proportion of the pelican population in an area (O'Malley and Evans 1982a). The significance levels reported are for median tests, comparing the medians of highly-skewed distributions.

Results

Arrival at the foraging area

Pelicans observed arriving at Grand Rapids from the colony (south) used both soaring and flap-gliding flight, but the latter was more common (Table 1). Few arrivals occurred before 1000, and those after 2000 were often associated with northerly (head) winds of at least 30 km/h (Figure 2A). As expected, soaring was most common during the afternoon when thermals were most abundant and well-developed. Flap-gliding flocks were significantly larger than soaring flocks ($x = 5.1$ vs. 1.8, $P < 0.001$). The difference was mainly due to the tendency of White Pelicans to disperse into smaller groups once they have gained altitude in thermals and begun soaring (O'Malley and Evans 1982a). Many birds arriving from the colony continued northward past the study area (Table 1), although some members of those flocks often "dropped out" to our area.

We recorded the destinations of individuals from most of the larger flocks which split up as they arrived. Among the 1209 pelicans in 148 flocks in the sample, 702 continued northward, and the rest landed on the river, at the dam, or more commonly joined a loafing group (Table 1). Eighty-nine flocks divided into two groups, birds from 27 flocks landed at three different sites, and the rest of the flocks sent pelicans to four or more locations. On five occasions when several flocks arrived simultaneously, the birds coalesced into a large group from which there were departures to a number of locations, while two or three new flocks formed and continued farther north. The continuing groups landed near the mouth of the river, or flew farther along the shore of Lake Winnipeg.

Other pelicans moved into or through the study area from the north. About 36% of the birds coming from the north continued past our site toward the colony (Table 1). A major influx of low, flap-gliding flocks, mainly from the mouth of the river, began each day as sunset approached; 60% of all birds arriving from the north were observed between 2030 and 2230 (Figure 2B). Among the birds from the north that landed, 55% landed on the river, 10% at the dam, and the remainder moved directly to loafing bars, in

TABLE 1. Number of birds and flocks observed arriving from the south and north at Grand Rapids.

	Arrivals from south					
	Soaring		Flap-gliding		Total	
Landing site	Birds	Flocks	Birds	Flocks	Birds	Flocks
Loafing group	134	84	548	177	682	261
River	60	42	119	68	179	110
Dam	223	139	73	27	296	166
Continued north	66	9	1476	164	1542	173
Total	483	274	2216	436	2699	710
	Arrivals from north					
	Soaring		Flap-gliding		Total	
Landing site	Birds	Flocks	Birds	Flocks	Birds	Flocks
Loafing group	–	–	432	185	432	185
River	–	–	694	279	694	279
Dam	27	13	102	58	129	71
Continued south	139	19	555	78	694	97
Total	166	32	1783	600	1949	632

marked contrast with the pelicans arriving from the colony. Few flocks from the north were soaring, probably because most birds from the north were moving relatively short distances between foraging areas.

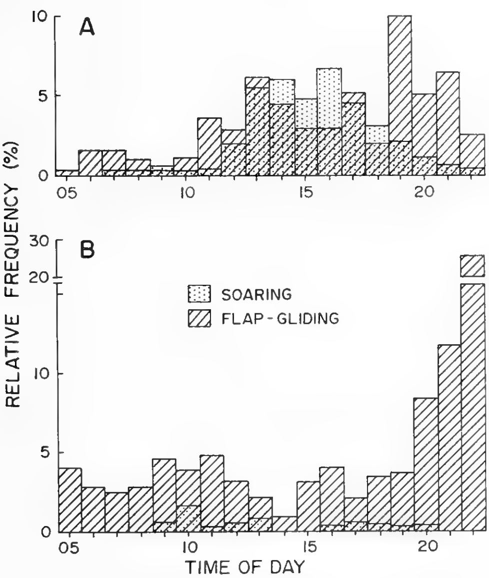

FIGURE 2. Daily patterns of flap-gliding and soaring flock arrivals at the study area from the south (A) and north (B).

We recorded the sizes of foraging flocks near which small flocks and single birds arriving from the south ($N = 85, \bar{x} = 1.4$) and from the north ($N = 184, \bar{x} = 1.3$) landed. Thirty-eight of the former and 68 of the latter flocks landed alone. The mean sizes of pelican foraging flocks selected by arrivals from the north (5.3 birds) and south (3.4 birds) were not significantly different. The foraging flocks selected by arriving pelicans were significantly larger than if they had been selected at random ($P < 0.001$). Similarly, loafing groups selected by arrivals from both directions were significantly larger than expected if selection was random ($P < 0.001$). The sizes of loafing groups joined by individuals and flocks from the south ($N = 178, \bar{x} = 2.5$) and north ($N = 112, \bar{x} = 2.2$) were not significantly different (49.5 vs. 44.8 birds, respectively). Only two birds from the south and four from the north initiated new loafing groups.

Departure from the foraging area

Flocks departing to the south from the foraging area originated most often among pelicans on the loafing bars (Table 2). The formation of a travelling flock was often signalled by a movement to the water at the edge of a loafing bar, which occasionally involved all but a few individuals on an island. Eventually such birds took flight en masse and were joined by other birds from the bars, and to a lesser extent by birds scattered over the water. Some of the latter appeared to have been actively foraging. However, most pelicans returned to a loafing bar between completion of foraging and departure to the colony; only 18% of the departing birds were on the water away from a loafing bar when they departed. The process of

TABLE 2. Number of birds and flocks observed departing to the south and north from Grand Rapids.

	Departures to south					
	Soaring		Flap-gliding		Total	
Initiation site	Birds	Flocks	Birds	Flocks	Birds	Flocks
Loafing group	815	394	1603	681	2418	1075
Water – foragers	69	43	167	78	236	121
Water – non-foragers	73	33	205	74	278	107
Total	957	470	1975	833	2932	1303

	Departures to north					
	Soaring		Flap-gliding		Total	
Initiation site	Birds	Flocks	Birds	Flocks	Birds	Flocks
Loafing group	1	1	363	157	364	158
Water – foragers	29	7	183	76	212	83
Water – non-foragers	–	–	4	2	4	2
Total	30	8	550	235	580	243

flock formation was thus similar to that observed when pelicans leave a colony en route *to* a foraging area (O'Malley and Evans 1982a), in that departures were strongly clumped, and there appeared to be overt flock recruitment behavior. The clumping of departures was most obvious in the early afternoon when only a few pelicans remained in the area. After perhaps an hour with no departures, a few birds suddenly left their loafing bars, joined together in a flock, and flew away southward.

Pelicans in soaring flocks represented one-third of the departures to the south, but were not common until after 0830 (Figure 3A). Flap-gliding predominated until that time. Over 80 % of the southbound birds left before 1030, but, surprisingly, departures continued sporadically until as late as 2116 (Figure 3A).

Seventeen percent of all departing birds travelled north, away from the breeding colony (Table 2). Although movement past the artificial boundaries of the study area occurred throughout the day (Figure 3B), 38 % of the movement was observed between 0430 and 0530. Most of that movement was related to local foraging activity rather than to travelling, as evidenced by the larger proportion, relative to southward departures, of flocks originating among actively foraging birds (Table 2). Later in the day a number of birds flew north and joined flocks soaring southwards from foraging sites farther north. Those flocks that continued past the study area toward the colony (Table 1) were significantly larger than soaring flocks leaving the study area directly ($P < 0.003$). The former had been in flight longer and therefore had more time to undergo growth.

Daily activity at the foraging site

The largest total population in the study area (average 369) was always recorded at 0430 (Figure 4). Departures continued steadily until the minimum daily population was reached at mid-day. The number of pelicans at Grand Rapids increased from mid-day onward as birds returned from the colony and from other foraging sites to the north.

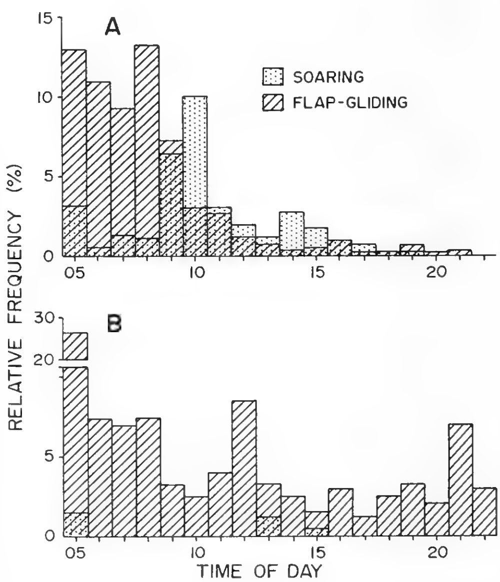

FIGURE 3. Daily patterns of flap-gliding and soaring flock departures from the study area to the south (A) and north (B).

More pelicans were loafing than foraging throughout most of each day (Figure 4). The proportion of pelicans foraging reached a daily minimum of 19 % at 2000. Most birds arriving before 2000 joined loafing groups and did not forage immediately. The number and proportion of foraging birds increased rapidly from 2000 to 2230. The increase in foragers initially resulted from an influx of pelicans from the mouth of the river. As sunset approached these birds always joined others that had already left the loafing bars. The rate of movement from the loafing bars to the water accelerated as more birds took to the water, and the numbers left on the bars declined accordingly (Figure 4).

Pelicans continued to move into the study area from downstream until about midnight, but there was simultaneous movement back downstream. Although accurate counts were not possible after 2230, it appeared that most of the local population engaged in foraging from midnight to 0300. After 0300 they began returning to the loafing bars where they slept and preened before undertaking the return flight to the breeding colony. The proportion of birds in the study area foraging dropped to an average of 53 % at 0430, when sunrise permitted the first accurate counts.

Discussion

The daily activity pattern we observed at Grand Rapids is consistent with activities of White Pelicans in other areas where foraging occurs at night and in the early morning (Low et al. 1950; Schaller 1964). The pattern is also similar to those reported for the Pink-backed Pelican (*P. rufescens*) and Great White Pelican (*P. onocrotalus;* Din and Eltringham 1974), and the Dalmation Pelican (*P. crispus;* Crivelli and Vizi 1981). Australian Pelicans (*P. conspicillatus*) fished during all hours of the day, but activity did not seem to be concentrated during any period (Vestjens 1977).

Many freshwater fish, including species utilized by White Pelicans (references cited above), are most active at night and in the twilight periods when they swim closer to the surface to forage (Carlander and Cleary 1949; Lawler 1969). They should be more vulnerable to predation by pelicans at that time, and it is not surprising that pelican foraging activity was greatest then. Although it was not possible to determine whether the pelicans foraged by touch, vision, or a combination during the day, vision may certainly be discounted during nocturnal foraging bouts.

The pelicans further improved their foraging pros-

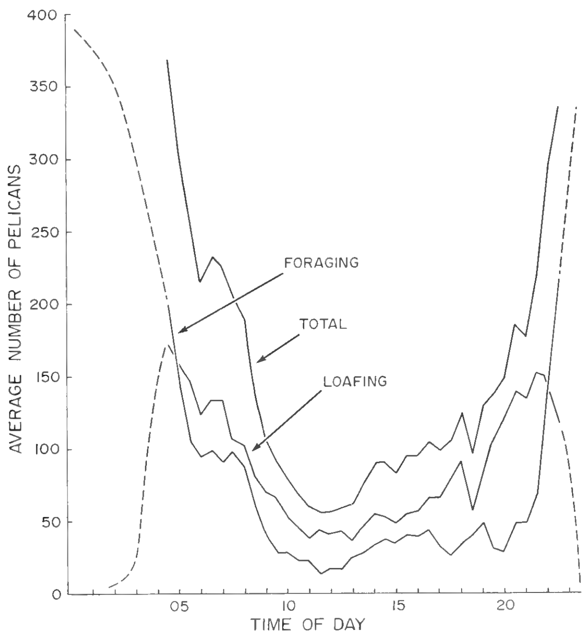

FIGURE 4. Average diurnal pattern in the number of White Pelicans loafing and foraging at Grand Rapids.

pects by concentrating their activity in the shallower water along the shore. The hydroelectric dam also provides the opportunity to forage successfully during the day, as fish that pass through the turbines are dazed and brought to the surface below the dam. Daytime foraging was much less common at the mouth of the river and on Cross Lake.

Another important factor affecting the daily activity pattern is the efficiency of daytime travel to and from the colony. Leaving a colony in a flock rather than singly appears to facilitate the use of local enhancement for locating thermals, and can provide aerodynamic or energetic advantages (O'Malley and Evans 1982a,b). Those benefits should also apply to the return trip to the colony, and may be even more important at that time because the returning birds carry an additional load of fish for their young. Fish caught by White Pelicans range from minnows to Carp (*Cyprinus carpio*) weighing over 2 kg (Alcorn 1943). Hall (1925) reported that 55-day-old pelicans ate 1.8 kg of food per day. Even if half was supplied by each parent, the load would constitute a significant addition to adult body weight. Evolution of the ability to use soaring flight in thermals was likely a contributing factor in extending their flight range for foraging under those circumstances. Foraging at night frees the pelicans to travel during the day when thermals occur, and when vision, which is required for local enhancement and formation flight, is best.

The mass movement of pelicans from the loafing islands to the water prior to travelling flock formation may be a mechanism for flock recruitment similar to the short flights from the nesting islands which typically involved a few "stimulus" birds (O'Malley and Evans 1982a). If flock travel conserves energy, as it appears to do, then individuals should try to ensure that they don't fly alone. In both of the above situations the obvious behavior exhibited may attract the attention of other individuals that are ready to travel, to their mutual benefit.

The flock size distributions and the proportions of soaring and flap-gliding flocks observed at Grand Rapids were similar to those recorded among pelicans departing a breeding colony in southern Manitoba (cf. O'Malley and Evans 1982b). The flock formation process apparently operates similarly in both situations. Similar flock formation at the colony and on the foraging sites was also found in Black-billed Gulls (*Larus bulleri;* Evans 1982), which appears to be the only other species for which similar information is available. As pelicans leaving the foraging area undoubtedly "know" how to get back to the colony, their employment of similar flock formation methods at the colony and foraging site argues against any specialized flock recruitment mechanisms that function solely for the purpose of searching for food i.e. information centers (see Evans 1982 for further discussion).

The observations of flocks arriving at the foraging area are perhaps more important than departures for assessing the relationship between flock flight and foraging activities. The significant preference of arriving birds for larger foraging flocks is likely a manifestation of local enhancement, a well-documented social foraging mechanism (Rand 1954; O'Malley and Evans 1983). In Great Blue Herons (*Ardea herodias;* Krebs 1974) and in Rooks (*Corvus frugilegus;* Waite 1981), larger foraging groups tended to collect at better local food sites. Similarly for pelicans, preferences for larger foraging flocks should increase an individual's chances of locating prey.

Flock travel from a colony could facilitate group foraging by ensuring the presence of a group at a foraging site (Knopf 1976; O'Malley and Evans 1982a). However, the observations reported here indicate flock travel was not essential for establishment of foraging groups at Grand Rapids. Almost 60 % of the birds arriving from the colony joined a loafing group before they began foraging, and many others joined existing foraging flocks. The fact that many birds left their travelling flocks to go to one area, while others continued to other locations, also argues against group maintenance being an important reason for flocking en route. The travelling flocks *per se* did not give rise to foraging flocks. Although those observations do not invalidate the hypothesis, they suggest that foraging-flock formation is not a likely function of flock travel to stable foraging grounds like the one we observed at Grand Rapids, and those reportedly used by pelicans in some other areas (Knopf and Kennedy 1980; Koonz 1981).

White Pelicans have nested at Kawinaw Lake and foraged at Grand Rapids for more than a decade (Lies and Behle 1966; Vermeer 1970; Koonz 1981). The site appears to be a traditional foraging area. If that is the case, flocks are not necessary to locate the area, as each individual presumably remembers how to get there. Young birds usually follow their parents on a foraging trip when they first leave the breeding colony (O'Malley and Evans 1982a), providing the opportunity to pass on that knowledge. Flight economy remains the most likely reason for flock travel by White Pelicans foraging at traditional sites like those examined in this study.

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Killer Whales, *Orcinus orca*, Prey on Narwhals, *Monodon monoceros*: An Eyewitness Account

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Steltner, Hermann, Sophie Steltner, and D. E. Sergeant. 1984. Killer Whales, *Orcinus orca*, prey on Narwhals, *Monodon monoceros*: an eyewitness account. Canadian Field-Naturalist 98(4): 458–462.

A first hand description is given of a herd or herds of several hundred Narwhals, *Monodon monoceros*, attacked by a herd of several tens of Killer Whales, *Orcinus orca*, in Eclipse Sound, Northwest Territories, in open water. The Killer Whales encircled the Narwhals by dividing into two groups which moved around the periphery of the prey animals in opposing directions. The attack by many killers at once then followed.

Key Words: Killer whales, *Orcinus orca*, Narwhales, *Monodon monoceros*, predation

The behaviour of the social Killer Whale, *Orcinus orca*, was reviewed by Martinez and Klinghammer (1969) who cite two references for predation by Killer Whales on Narwhals. One of these sources, however, is derived, and we are left with two primary sources Freuchen (1935) and Freuchen and Salomonsen (1958). Although Freuchen (1935) summarizes some Inuit observations on Killer Whale attacks, he himself saw only frightened potential prey species, Narwhals and seals seeking safety close to land at times of presence of nearby Killer Whales in the Pond Inlet area. Freuchen and Salomonsen (1958) give more information evidently also based mainly on Inuit reports:

"At Button Point (Bylot I.) the narwhals come fleeing into the leads when the killer whales appear. They sometimes stay for hours in the leads, the white whales with them, while beyond the edge of the ice, the killer whales travel up and down to keep watch, never seeming inclined to follow their quarry into the leads. And thus several hundred narwhals are usually killed by the natives every year" (p. 216).

"As soon as a killer whale appears, the narwhals and white whales try to escape, but killer whales are very fast. If they are alone they pursue a single narwhal, which often takes refuge in shallow water close to shore. In such situations, the killer whale . . . strikes with his powerful tail, and when the narwhal is found later it is observed that it always has its spine broken where the killer whale has hit it. Most of the time the killer whales travel in small herds. When they pursue a school of narwhals, they swim after them and go up to each side of a narwhal. Two of them then press the unfortunate smaller whale between them with such power that all his ribs break. They then go after the rest of the flock. The narwhal whose ribs are broken does not die immediately, but swims on the surface in circles, often spouting blood as he breathes" (p. 283).

Observations

The following first hand account by the Steltners is given verbatim with minor editing:

On Saturday, 30 August 1980, we both left with the 16 ft. 35 HP outboard boat at high noon from Pond Inlet to a point west of the Sermilik glacier to look at the glacier discharge flume direction during the change of tide at both glaciers, the Sermilik and the Kaparoqtalik on Bylot Island.

On the way across Eclipse Sound we spotted many Narwhals here and there, not moving in a herd formation. On the previous day, during a flight from Pond Inlet over the glacier route to the radar site at the NW corner of Bylot Island, over 300 Narwhals were sighted and counted from the air in the Eclipse Sound area, so that we expected to encounter quite a number out there on this Saturday.

It was a beautiful day; no wind, no cloud, and the temperature was 7°C, with visibility unlimited. The Eclipse Sound water surface mirrored the deep blue sky, with the high peaks of Bylot Island on one side and the mountains of Baffin Island on the other.

After completing our observations along the Bylot shoreline, we started our return trip to Pond Inlet from a point east of Kaparoqtalik glacier after the beginning of the outgoing tide, at 1530 EST.

About 1545 EST, we spotted the first herd of Narwhals moving at high speed from west to east at about the middle of Eclipse Sound, and within minutes several herds of Narwhals followed the first one, obviously in full flight, as some animals could be seen jumping out of the water full

length. Some Narwhals touched our boat from underneath in their frantic flight. We had stopped the engine to observe and were right in the middle of this turmoil of water-thrashing herds. There must have been several hundred Narwhals around us.

At the same time we spotted a large herd of Killer Whales, also moving east, at an even greater speed, literally flying out of the water, with their bellies and their eye patches flashing white.

This herd of Killer Whales, although hard to count, appeared to be between 30 and 40 large animals, about 8 to 10 m long, and some of the dorsal fins more than 1 m high sticking out of the water as they moved along. Whale screams could be heard all over the place as the Killer Whale herd passed right through the Narwhal herds.

About 400 m to the east of our location, all the Narwhals turned 180 degrees and now moved westward, whilst the Killer Whales continued for another five minutes in an easterly direction; and then the whole herd stopped. But the narwhal continued at their high speed generally to the west, some groups veering to the northwest and some to the southwest. The time was now 1605 EST. From the Killer Whale herd eight animals now started moving to the north-northwest, with their dorsal fins showing that they were moving along steadily, and there was no jumping. The bulk of the killers moved to the south-southwest after this first separation, but after a few minutes we still counted seven killers remaining at the same starting point (Figure 1).

At 1615 EST, the group of seven Killer Whales that had been more or less stationary until this time appeared to fan out to the north and, after moving about 1.5 km, turned around and now moved to the south for approximately 3 km.

The group of Killer Whales that had initially moved to the northwest was now due north from us at a distance of about 4 km.

By 1705 EST, the Narwhals were completely encircled by the killers and continued to move in small groups around us in all directions. The total number of Narwhals there was about two hundred (Figure 2).

Suddenly, all breathing noise ceased and everything was quiet. With so many animals around us, and having seen the corps of huge predators amongst their prey, the much smaller Narwhal, we were filled with eerie expectation. We watched as all the whales continued moving very slowly, so slowly that the long fins of the Killer Whales did not even cause a ripple on the mirror-smooth surface.

At 1714 EST, everything around us came to life and the Killer Whales started to attack. As far as we could see, the waters were whipped white by thrashing whales, while screams and shrieks were heard all around us, large bodies seemed to stand on end one second, and then with great splashes hit the water in the other. Mottled gray in all shades and black and white bodies slid through the water, now at the surface, now down to the deep, tail flukes glistening in the air.

At one point a Narwhal was seen rolling sideways on the surface, its mouth opened in high-pitched screams.

One such cauldron of commotion was only about 150 m from our boat and, while this was going on, several whales contacted its sides and bottom. But we were too absorbed in watching this rare spectacle and stayed quietly where we were. By 1720 EST, things had quietened down around us, when we noticed that the Killer Whale herds to the north, southwest, and east of us had started moving towards our location. This is when we started the outboard motor and, just after we started to move, we noticed a flock of gulls swooping down on something in the water about 50 m away from us. We steered towards this point and found floating about 1 m below the surface the bloody underbelly of a female Narwhal with some of the viscera streaming. We recovered this piece of Narwhal weighing approximately 150 lb (68 kg). The tooth marks of the Killer Whales could be seen all around the edges; they must have ripped it out by force.

We then continued towards Pond Inlet and, approaching the shore, we noticed great hunting activities for seals, which had literally hugged the shore together with Narwhal calves during the preceding hours. This had apparently occurred on both shores of the Sound, Bylot as well as Baffin, as later in the evening one hunter reported having caught five seals right at the shore of Bylot between the two glaciers, Sermilik and Kaparoqtalik, and others had been caught near Mount Herodier.

It is worth noting that the hydrographical features of the area where the above events took place include a sea mount which may have contributed to create acoustic and other conditions favourable for the Killer Whales and disorienting the Narwhal.

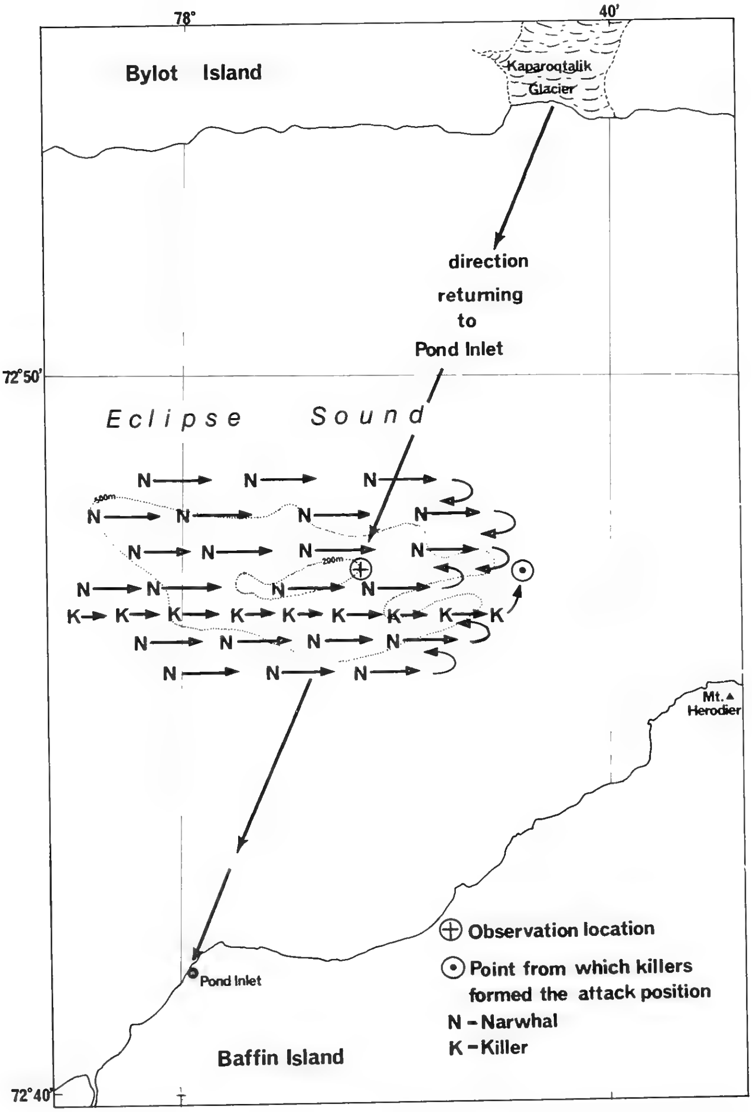

FIGURE 1. Early phase of Killer Whale attack. The Sermilik Glacier, mentioned in the text, is off the map to the north-west.

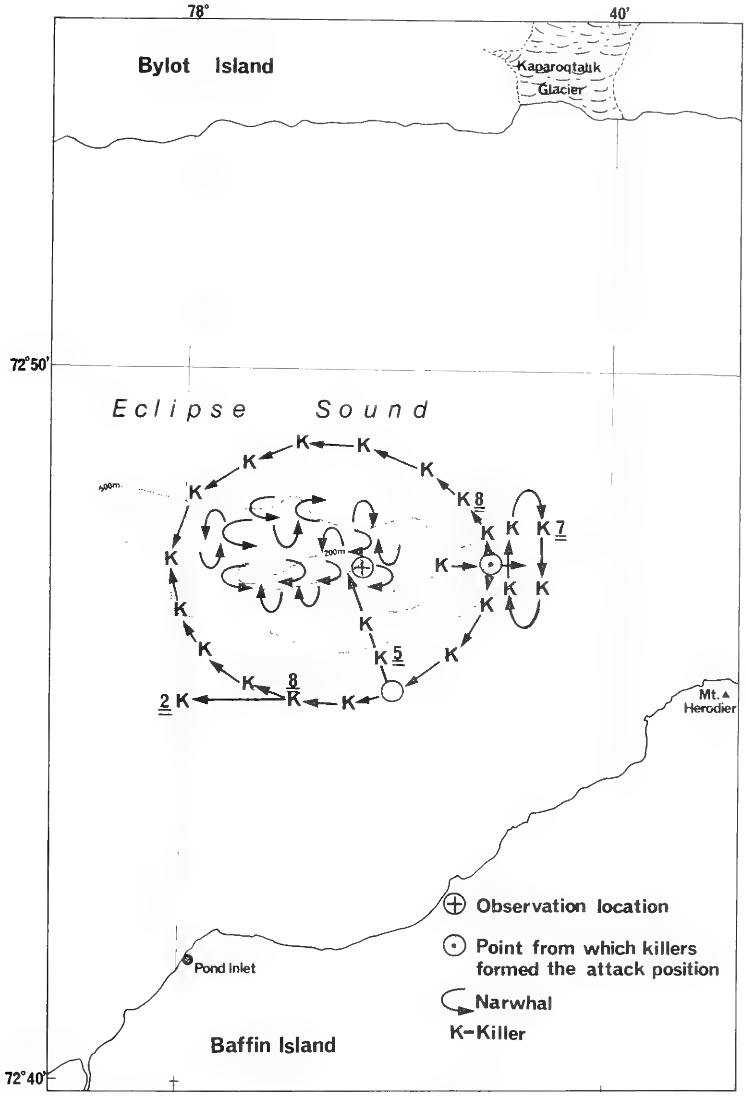

FIGURE 2. Later phase of Killer Whale attack.

The next day, local people came to visit: they wanted to hear all about this great predator attack, as only two Killer Whales had been seen from the shore near the village. However more seals than usual and a small Narwhal had been seen and one baby Narwhal corpse washed ashore on Bylot during the night.

"Were you frightened?" "You should have been frightened! These were the big ones, twice as big as the Narwhal!"

Yes, the Killer Whale used to be hunted for food sometimes. "But we needed to be very, very hungry, so much so that our hunger was greater than our fear of these Killer Whales."

Discussion

Few previous descriptions of predation by Killer Whales refer to attacks on a social Odontocete species. However Brown and Norris (1956) describe at second hand an attack on a school of dolphins in the North Pacific Ocean:

> Marineland's head diver, Ted Davis, while working aboard a tuna clipper, watched a group of 15 to 20 *Grampus* attacking a school of about 100 dolphins in the vicinity of Alijos Rocks, off Baja California, Mexico. This occurred during the fall of 1947. He reports that the killers swam in circles around the dolphin school, gradually crowding them tighter and tighter. Finally one of the killers veered off, rushing at the school, while the others continued circling. In this fashion, the killers ripped at the school one at a time, killing many of the dolphins. The water was red with blood. The dolphins were of a type called "white belly porpoises," by the tuna fishermen, presumably *Delphinus bairdi*.

Also Sleptsov (1952), cited by Kleinenberg, Yablokov, Bel'kovich and Tarasevich (1969), describing an attack by Killer Whales on Belugas stated that:

> The whales divided into two groups (3 whales in the first group and 5 whales in the second) which attacked the belugas simultaneously. The water was soon coloured with the blood of the belugas, and two reddish, greasy spots remained on the water after 20 minutes. Both the belugas and the killer whales submerged for 4-5 minutes; from time to time when they appeared again on the surface, it was possible to observe how the predators attacked the weakened animals.

This description and the attack of Narwhals reported in this paper have enough similarities to suggest a common pattern in attacks by Killer Whales on social Odontocetes, involving encirclement of the prey school, followed by individual or mass attack.

Acknowledgments

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Habitat Selection in the Southern Bog Lemming, *Synaptomys cooperi,* and the Meadow Vole, *Microtus pennsylvanicus*, in Virginia

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Habitat of the Southern Bog Lemming (*Synaptomys cooperi*) was compared quantitatively with habitat of the Meadow Vole (*Microtus pennsylvanicus*) in Montgomery County, Virginia. Three study grids were located along a vegetation gradient from deciduous woodland/grass ecotone to old-field habitat. Determination of relative abundance of *Microtus* and *Synaptomys* and analysis of vegetation structure on these grids indicated that *Synaptomys* is found where ground cover is sparse and woody vegetation more abundant. Land-use practices that convert sparsely grassed woodland to pastures would adversely affect *Synaptomys*, although creation of clearings in forested areas would favor this species.

Key Words: habitat, Southern Bog Lemming, *Synaptomys cooperi*, Meadow Vole, *Microtus pennsylvanicus*, discriminant function analysis.

The microtine rodents *Synaptomys cooperi* and *Microtus pennsylvanicus* are sympatric species that are similar in size, appearance, and diet (herbaceous vegetation). *Synaptomys* has been reported from a wide variety of habitats throughout its range, including sphagnum bogs (Howell 1927; Coventry 1942; Poole 1943; Odum 1949; Buckner 1957; Connor 1959), grasslands (Barbour 1956; Gaines et al. 1977), openings in woodlands (Stewart 1943; Smyth 1946; Barbour 1956; Kirkland 1977), and heavily forested areas with non-grass ground cover (Goodwin 1932; Hamilton 1941; Coventry 1942). Although population densities of *Synaptomys* are highest in midwestern grasslands of the United States, studies in that region record the presence of shrubs in areas where *Synaptomys* occurs (Getz 1961; Gaines et al. 1977; Rose and Spevak 1978). Despite these casual observations, habitat characteristics of *Synaptomys* have never been quantitatively defined. On the other hand, the association of *Microtus* with heavy grass cover is well known, as is the fact that *Microtus* usually avoids woodland habitats (Eadie 1953; Getz 1961, 1970; Birney et al. 1976). Ecological relationships of *Synaptomys* are poorly understood in the eastern United States and Canada, where this species occurs in low densities and is infrequently captured. The present study compares vegetational characteristics of *Synaptomys* and *Microtus* habitats in an attempt to quantify patterns of habitat use by these species.

Study Area

The study area is situated above the valley of the North Fork of the Roanoke River (518–533 m), east of Blacksburg, Montgomery Co., Virginia (37°13′N, 80°23′W) (Figures 1 and 2). Three 0.25 ha sampling grids (5 m station interval) were established in habitats reflecting a vegetation gradient from deciduous woodland/grass ecotone to an open field with tall dense grass cover (Figure 2). A detailed description of the vegetation is given in Linzey (1981). Physical characteristics of the area, including scattered limestone outcrops and thin topsoil underlain by heavy clays, resemble cedar glades of Wisconsin and Missouri (Kucera and Martin 1957; Curtis 1959). The area is located within the Allegheny Mountain region of Virginia's Ridge and Valley Province (Hoffman 1969).

Two sampling grids were located in habitats dominated by Eastern Red Cedar, *Juniperus virginiana*, and Broomsedge, *Andropogon scoparius* (Figure 2). The Cedar grid was within the deciduous woodland/grass ecotone and had a heterogeneous mixture of microhabitats ranging from grassy patches with little tree canopy to shaded areas with deciduous leaf litter. The Indian Run grid was more homogeneous, with a continuous cover of *Andropogon*, large scattered cedar trees, and a few small deciduous trees and shrubs. The third grid, Layne Field, was in an area that had been converted from *Juniperus*/*Andropogon* to pasture and then abandoned. It had a dense growth of introduced grasses and a few large cedar trees, but almost no deciduous trees and shrubs.

Materials and Methods

As part of a more extensive study of *Synaptomys*, the Cedar grid was sampled by live trapping from July 1978–June 1979. Trapping was done monthly, with one small Sherman trap per station (98 stations) set for four nights. Although this technique established the presence of *Synaptomys*, six different individuals

FIGURE 1. Map of eastern United States and southeastern Canada; dot indicates general geographic location of study area.

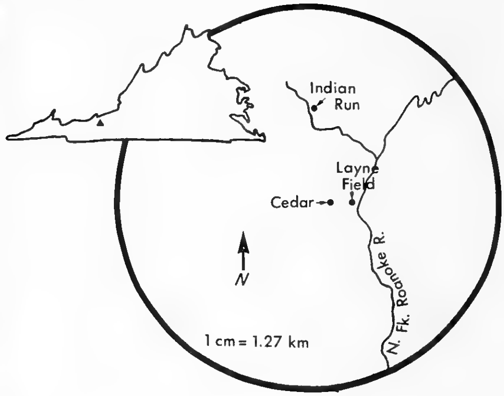

FIGURE 2. Relative location of three study grids. Insert map shows location of study area in southwestern Virginia (triangle).

were captured only 16 times during the sampling year. In contrast, eight different *Microtus* entered live traps 39 times. This differential response to trapping made it necessary to find another sampling technique that (1) would more quickly and reliably assess population density of *Synaptomys*, (2) would give more comparable results for *Microtus* and *Synaptomys*, and (3) could be used intensively without disturbing animal populations. Field testing of dropping boards indicated that they would be an appropriate sampling tool and they were used throughout the remainder of the study. Dropping stations were first employed by Eadie (1948) to collect *Blarina* scats for food habits analysis, and Mossman (1955) used them to assess distribution of *Microtus* relative to cover density. Although the technique was extensively tested by Emlen et al. (1957), it has seldom been used since then.

Dropping boards were cut to fit in runways (exterior plywood, 0.6 by 6.5 by 15 cm). One board was placed at each trap station and one in the center of each square formed by four stations (181 boards per 10 by 10 grid). Boards were cleared every second day (five times during a 10-day sample period) and data were recorded as total number of visits (one visit = one or more droppings on a board during a two-day interval) by each species. Successful use of the dropping board technique depends on accurate identification of scats. *Synaptomys* droppings are distinctively green, but those of *Microtus* are brown or black (Burt 1928; Cockrum 1952; Connor 1959). Also, *Synaptomys* droppings are smaller, blunt at both ends, and deposited singly; those of *Microtus* are blunt at one end, pointed at the other, and often adhere in groups of two to five. The only other small mammal that used the dropping boards was *Blarina brevicauda*, the droppings of which are distinctively amorphous.

The value of dropping boards to index relative population size was demonstrated by Emlen et al. (1957), who found that the number of droppings per board per time interval was a poor index, but that frequency of visits to boards was positively correlated with population size. The relationship between frequency of board use and population size in *Microtus* during the present investigation was determined by conducting 10-day board surveys followed by four-day live trapping sessions. This test involved two different grids in summer and winter ($n = 5$), thus incorporating variation in habitat and season. Population size was estimated by minimum number known alive, MNA (Krebs 1966). Analysis of the relationship between population size and frequency of board visits indicated that the two measures are highly correlated ($r = 0.90$, $y = 10.25 \times + 11.28$, $p < 0.05$). Population density of *Synaptomys* was determined during two tests. In one case, 55 visits to boards were recorded during a ten-day survey period. Six *Synaptomys* were taken during subsequent removal trapping. Similarly, on another grid, live-trapping revealed that five *Synaptomys* were responsible for 59 visits to dropping

boards. These estimates indicate that comparisons using the dropping board technique may slightly underestimate *Synaptomys* numbers (4.2 animals predicted by 55 visits; 4.6 animals predicted by 59 visits).

Vegetation analysis consisted of measuring density of ground cover, trees, and shrubs by means of cover estimates and direct counts. Descriptions of variables are given in Table 2. Cover estimates were made during August at peak grass/forb development. Tree/shrub counts were made during two summers (1979, 1980) and were completed before leaf fall. Sampling units were squares formed by grid sampling stations (25 m^2). Sampling intensity was 100% (n = 78) on the Cedar grid and 33% (n = 27, randomly chosen) on the Indian Run and Layne Field study areas.

Cover estimates were obtained by using a 0.5 by 1 m cover board divided into three vertical levels (0–25 cm, 25–50 cm, 50–100 cm), with each level marked off in equal units (M'Closkey and Fieldwick 1975; Schreiber et al. 1976). The board was placed in the center of a grid square in a randomly chosen position. Percentage of area covered was estimated by reading both sides of the board, and final values for each category were obtained by averaging the two sides. Distance from observer to board was standardized at 75 cm because on the grid with densest ground cover this resulted in values consistently below 100%. This technique was designed primarily to quantify grass/forb cover and was less efficient as an estimator of tree/shrub density. Hence, direct counts of trees and shrubs in several height classes were also made on each sampled square. Shrub counts were based on numbers of vertical stems. When density of blackberries (including dewberries, *Rubus* sp.) exceeded 100 stems/square, the square was assigned a value of 100.

Statistical tests for normality indicated that nearly all variables showed significant skewness and/or kurtosis, although distributions of all variables were unimodal. Data were not transformed because of a preponderance of zero values for some variables. Discriminant function analysis (DFA) was used as a statistical tool to detect habitat differences between study grids. A stepwise routine (SPSS STEPWISE) selected variables that, in linear combination, contributed most to group separation (Nie et al. 1975). However, due to violations of assumptions of normality and homogeneity of within-group variance-covariance matrices, a formal test of no difference in habitat is not statistically valid (Green 1979). Duncan's multiple range test was used to detect statistically significant differences in individual variable means.

Results

Dropping board indices of population density in *Microtus* indicated that *Microtus* was least abundant on the Cedar grid and most abundant on the Layne Field (Table 1). *Microtus* had been present on the Cedar grid during the first six months (July 1978–January 1979) of live-trapping, but was not caught after January 1979. Absence of *Microtus* from the Cedar grid during spring and summer 1979 and subsequent recolonization, reflected an area wide four-year population cycle. *Microtus* populations in optimal habitat reached maximum densities of 398/ha in October 1978 and declined to 27/ha in March 1979 (Cranford, unpublished data). Regardless of the status of the *Microtus* population, *Synaptomys* was most abundant on the Cedar grid, rare at Indian Run, and absent from the Layne Field. However, a decline in *Synaptomys* numbers on the Cedar grid between 1979 and 1980 coincided with the increase in *Microtus* density (Table 1).

A comparison of vegetation characteristics of habitat where *Synaptomys* was most abundant (Cedar grid) with habitat where *Microtus* was most abundant (Layne Field) reveals significantly less grass cover and significantly more small and medium height trees, small shrubs (both categories) and large shrubs (other than *Rubus*/*Rosa*) in the *Synaptomys* habitat (Table 2). Means for these variables at Indian Run were either intermediate or similar to the Layne Field. The abundance and height of forbs reflected openness of the habitat. Forbs were sparse on the Cedar grid and remained small in this semi-shaded habitat. Small and medium height forbs were abundant at Indian Run, and tall forbs dominated the Layne Field. The large

TABLE 1. Number of visits to dropping boards during two ten-day sample periods in summer 1979 and summer 1980 (boards cleared every two days). Number of board units (one board unit = one board set for two days) indicates sampling intensity.

		1979		1980	
Grid	Board Units	*Microtus*	*Synaptomys*	*Microtus*	*Synaptomys*
Cedar	880	0	59	27	24
Indian Run	905	55	0	47	3
Layne Field	905	444	0	360	0

TABLE 2. Sample estimates of the means and standard errors (in parentheses) for habitat variables on three study grids (n = number of squares). Means not differing significantly are designated by the same letter (Duncan's multiple range test, $p > 0.05$).

	Cedar Grid n = 78	Indian Run n = 27	Layne Field n = 27
% Cover		0-25 cm high	
Grass	^{b}53.7 (3.34)	^{a}76.7 (5.45)	^{a}90.6 (2.60)
Forb	^{b} 3.4 (0.47)	^{a} 9.6 (3.58)	^{b} 3.5 (1.26)
Shrub	^{a} 3.1 (0.56)	^{b} 0.6 (0.41)	^{b} 1.2 (1.03)
Tree	^{ab} 2.2 (0.53)	^{b} 0.4 (0.29)	^{b} 0.0 (0.00)
		26-50 cm high	
Grass	^{c} 5.1 (0.66)	^{b}19.0 (2.51)	^{a}45.9 (5.02)
Forb	^{c} 1.4 (0.28)	^{a}19.1 (4.82)	^{b} 7.1 (1.68)
Shrub	^{a} 3.2 (0.70)	^{a} 7.5 (0.58)	^{a} 2.2 (1.65)
Tree	^{a} 3.6 (0.73)	^{ab} 2.2 (0.93)	^{b} 0.0 (0.00)
		51-100 cm high	
Grass	^{c} 0.2 (0.04)	^{b} 1.6 (0.26)	^{a} 7.4 (1.07)
Forb	^{c} 0.4 (0.18)	^{b} 5.6 (1.95)	^{a} 9.1 (1.91)
Shrub	^{a} 1.0 (0.46)	^{a} 0.1 (0.09)	^{a} 0.1 (0.06)
Tree	^{a} 6.8 (1.06)	^{ab} 4.4 (1.61)	^{b} 0.3 (0.28)
Number of Trees		< 1 m high	
Deciduous	^{a}13.0 (1.93)	^{b} 1.7 (0.55)	^{b} 0.5 (0.20)
Evergreen	^{a}10.2 (1.09)	^{b} 1.2 (0.49)	^{b} 0.0 (0.04)
		1-4 m high	
Deciduous	^{a} 8.0 (2.00)	^{b} 1.2 (0.57)	^{b} 0.1 (0.08)
Evergreen	^{a} 6.4 (0.57)	^{b} 1.6 (0.37)	^{b} 0.5 (0.13)
		> 4 m high	
Deciduous	^{a} 0.2 (0.09)	^{a} 0.0 (0.04)	^{a} 0.0 (0.00)
Evergreen	^{ab} 1.2 (0.12)	^{bc} 0.8 (0.18)	^{c} 0.1 (0.07)
Number of Shrubs		< 0.5 m high	
Rubus/Rosa	^{a}94.6 (1.55)	^{b}41.2 (6.47)	^{c}18.3 (6.21)
Other	^{a}15.1 (3.27)	^{b} 0.2 (0.11)	^{b} 0.0 (0.00)
		> 0.5 m high	
Rubus/Rosa	^{b} 0.6 (0.34)	^{a} 4.5 (2.34)	^{a} 8.2 (3.01)
Other	^{a} 6.1 (1.72)	^{b} 0.2 (0.12)	^{b} 0.1 (0.05)

Rubus/Rosa shrub category was composed mostly of tall blackberry canes (*Rubus allegheniensis*), which were least abundant on the shady Cedar grid and most abundant on the open Layne Field.

Discriminant function analysis of vegetation data indicated that 13 variables contributed significantly to separation of the three habitats (Table 3). Discriminant function 1 explained most of the variance (91.86%); variables contributing most to this function were grass cover (low, medium, high), forb cover (medium and high), and *Rubus/Rosa* shrubs (both heights). The general tendency expressed by the signs (+ or −) of the discriminant function coefficients was an inverse relationship between ground cover and tree/shrub cover. A scatterplot of discriminant scores for each study grid shows that *Synaptomys* habitat (Cedar grid) is well segregated from *Microtus* habitat (Indian Run, Layne Field) (Figure 3). Conversely, individual sample squares were assigned to the correct grid with a high degree of accuracy (85.2–100%) (Table 3), indicating that the variables selected can be used to predict species' occurrence in a given habitat type.

TABLE 3. Summary of stepwise discriminant function analysis comparing Cedar, Indian Run, and Layne Field habitats.

	Discriminant Functions #1	#2
Eigenvalue	8.94358	0.79236
% Variance	91.86	8.14
Chi-square Statistic	349.98	70.90
Significance	0.0	0.0
Degrees of Freedom	28	13

Variable	Standardized DF Coefficient #1	#2
Grass 0–25 cm	0.29742	-0.48232
Grass 26–50 cm	0.26879	-0.00553
Forb 26–50 cm	0.45465	-1.09392
Shrub 26–50 cm	0.22820	-0.03259
Tree 26–50 cm	0.24552	-0.35107
Grass 51–100 cm	0.31612	0.58029
Forb 51–100 cm	0.15697	0.69754
Shrub 51–100 cm	-0.25083	0.03993
Deciduous trees < 1 m	-0.19220	0.21029
Deciduous trees 1–4 m	-0.26094	0.13019
Evergreen trees 1–4 m	-0.60062	0.39522
Rubus/Rosa shrubs < 0.5 m	-0.83015	0.08361
Rubus/Rosa shrubs > 0.5 m	0.49780	0.15380

Classification Matrix

Actual Group	n	Predicted Group Membership (%) Cedar	Indian Run	Layne Field
Cedar	78	100.0	0.0	0.0
Indian Run	27	7.4	85.2	7.4
Layne Field	27	0.0	7.4	92.6

Discussion

The results of this study demonstrate that *Synaptomys*, in comparison with *Microtus*, is found in habitats having more woody plants and sparser grass cover. The *Juniperus/Andropogon* habitat (Cedar grid) frequented by *Synaptomys* in this study supported extremely low densities of *Microtus*, a reflection of poor cover conditions and of the fact that *Andropogon* is a poor food for *Microtus* (Cole and Batzli 1979). The Layne Field, where *Andropogon* has

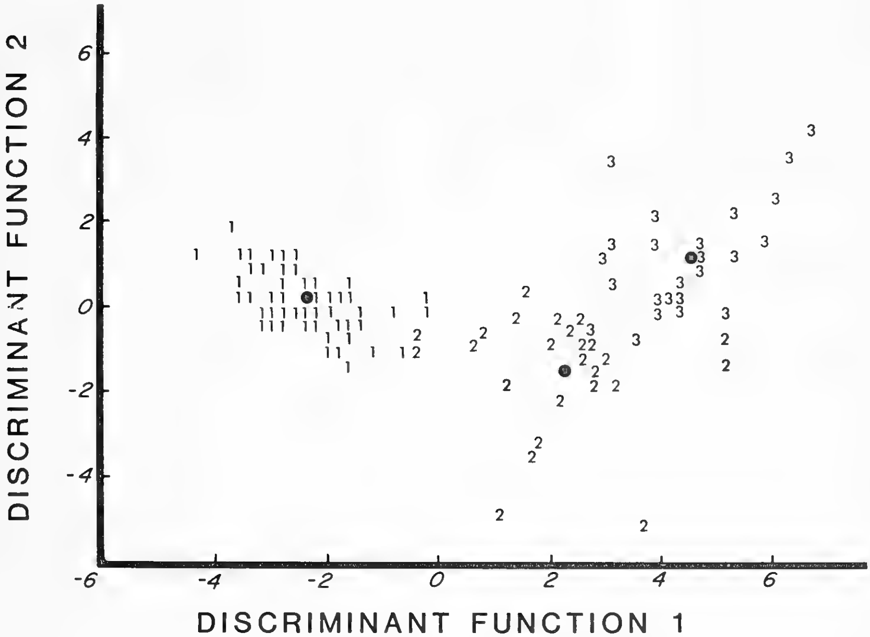

FIGURE 3. Scatterplot of discriminant function scores for each habitat. 1 = Cedar Grid; 2 = Indian Run Grid; 3 = Layne Field Grid. Dots indicate location of group centroids.

been replaced by introduced grasses and where forbs are also present, provides the best *Microtus* habitat. The fact that *Synaptomys* attains greater densities in the central plains states of the United States (Gaines et al. 1977, 1979) suggests that low densities in the eastern United States and Canada are not due to intrinsically lower reproductive rates, but may reflect poorer cover and food resources that are lower in digestible energy and nutrients.

Habitat selection by *Synaptomys* might result from either preference or availability. Concurrent removal experiments and observations of *Synaptomys* microhabitat during a *Microtus* population cycle indicate that *Synaptomys* prefers habitats normally occupied by *Microtus*, but gains access only to extremely poor *Microtus* habitats during the low phase of the *Microtus* population cycle (Linzey 1984). Even habitats of marginal quality for *Microtus* (Indian Run) are unavailable to *Synaptomys* if *Microtus* maintains minimal densities. Studies indicating that *Microtus ochrogaster* is behaviorally dominant to *Synaptomys* (Rose and Spevak 1978) and that the rate of dispersal by *Synaptomys* increases with increasing *Microtus* density (Gaines et al. 1979) provide additional support for the contention that distribution of *Synaptomys* is affected by competition with *Microtus*. These observations emphasize the need for careful qualification when describing habitat "preferences" of any species.

Quantification of habitat affinities of *Synaptomys* is of particular interest because of concern regarding the status of this species in several parts of its range. *Synaptomys* is referred to as rare in the Appalachian region (Kirkland 1977) and given the status of "special concern" in North Carolina (Lee and Funderburg 1977). The race inhabiting the Great Dismal Swamp of coastal Virginia and North Carolina (*S. c. helaletes*) was only recently "rediscovered" after a collecting hiatus of 82 years (Rose 1981). It is clear that the distribution of *Synaptomys* can be affected by human activities. Land use practices that convert open woodlands to pastures and that replace native grasses with introduced species will favor *Microtus*. However, the creation of clearings (clearcuttings, powerline rights-of-way) in the midst of extensive forested habitats will favor *Synaptomys*, especially if the probability of colonization by *Microtus* is low.

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Shumard Oak, *Quercus shumardii,* in Essex County, Ontario

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Shumard Oak (*Quercus shumardii*) is reported from the bottom lands of Essex County, Ontario. This location is at the same northern latitude as Shumard Oak locations mapped for southern Michigan. The leaf and acorn morphology, as well as bark and tree habit are variable and this may indicate a Shumard Oak hybrid complex, mainly with Pin Oak (*Quercus palustris*) and to a minor degree with Red Oak (*Quercus rubra*). Shumard Oak, with about 500 scattered trees remaining in Essex County, occurs in private wood lots, conservation areas and parks of Windsor. Few trees with typical Shumard Oak features remain in this deforested County and an effort has been undertaken to establish seedling populations.

Key Words: *Quercus shumardii,* hybrids, distribution, Essex County, Ontario

Quercus shumardii (Shumard Oak) is classified in the subgenus *Erythrobalanus* (Red and Black Oaks), together with *Q. rubra* (Red Oak), *Q. velutina* (Black Oak), *Q. palustris* (Pin Oak), *Q. coccinea* (Scarlet Oak), and *Q. ellipsoidalis* (Hill's Oak); and each species is considered to be reasonably distinct (Jensen 1977a and b). Until recently only Red Oak, Black Oak and Pin Oak had been reported for southern Ontario, with records of Scarlet Oak being referred to Black and Pin Oaks (Fox and Soper 1954). In nearby Michigan, Scarlet Oak[1] and Hill's Oak occur with reasonable frequency in the well-drained sandy areas of the southern part of Michigan (Barnes and Wagner 1981), but Shumard Oak is not listed. Shumard Oak, however, has a wide, though scattered, distribution through eastern and Central United States (Little 1971) and it had been previously reported from Kalamazoo County, Michigan (Hanes and Hanes 1947). Its northern distribution is shown in Figure 1a (based on Fowells 1965). This tree occurs frequently on the low bottomlands of Indiana (Deam 1953) and Braun (1961) maps it for northern Ohio. Wagner and Schoen (1976) reported on the occurrence of yet another oak, *Quercus imbricaria* (Shingle Oak) in the southern part of Michigan, indicating the penetration of southern *Erythrobalanus* types of oaks in the past into these more northern localities. Then followed the reports on the occurrence of Hill's Oak in northwestern Ontario (Maycock et al. 1980) and the same species in Brant and Waterloo Counties (now the Regional Municipality of Waterloo) in southern Ontario by Ball (1981).

In 1978, G. E. Waldron[2], prevented the removal of a Shumard-like Oak near Paquette Corners, Essex County, Ontario. Collections from this tree compared closely with authentic material of southern Shumard Oak available at the herbarium of the University of Michigan, Ann Arbor, Michigan. Waldron (1982, Status Report on Shumard Oak: submitted to the Plant Subcommittee of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 22 pp.) maps the extent of Shumard Oak for Essex and Kent Counties, Ontario reaching Chatham (see Figure 1B), with one tree located near West Lorne, Elgin County, Ontario. Waldron reports it from the rich bottomlands with clay and clay loam of the Brookston, Perth, and Toledo series. All three soil types feature poor internal drainage with surface water accumulating during winter and spring. The report by Waldron indicates 14 collections and 19 sight observations with specimen deposited in the herbaria of the University of Michigan (M), the University of Western Ontario (UWO), University of Guelph (OAC) and the University of Toronto (TRT).

Shumard Oak, like many other oaks, is reported to hybridize with other oaks, such as Pin Oak (Fowells 1965) and when looking at these Shumard-like Oaks in Essex County it became apparent that Shumard Oak may occur here as an intermediate with other oaks. For this reason we have examined these Shumard-like Oaks and made collections to appraise this situation as it occurs in Essex County. These collections and an index to the collections were deposited at the herbarium of the Ojibway Nature Centre, Windsor Department of Parks and Recreation, Windsor, Ontario, N8X 3N6. This index to these collections of Shumard Oak (*Quercus shumardii*) and its hybrids in Essex County, has been placed in the Depository of Unpublished Data, CISTI, National Research Council of Canada, Ottawa, Canada, K1A 0S2, which is available at a nominal charge from this Depository.

[1]Black Oak x Hill's Oak hybrids which are well documented in Michigan and Wisconsin, can easily be mistaken for Scarlet Oak and its identification in Michigan is problematic.

[2]Harrow Research Station, Harrow, Ontario. A number of acorns were collected at the Devonwood Conservation area, Windsor, in 1980 and listed in the University of Guelph Arboretum seedlist for 1980.

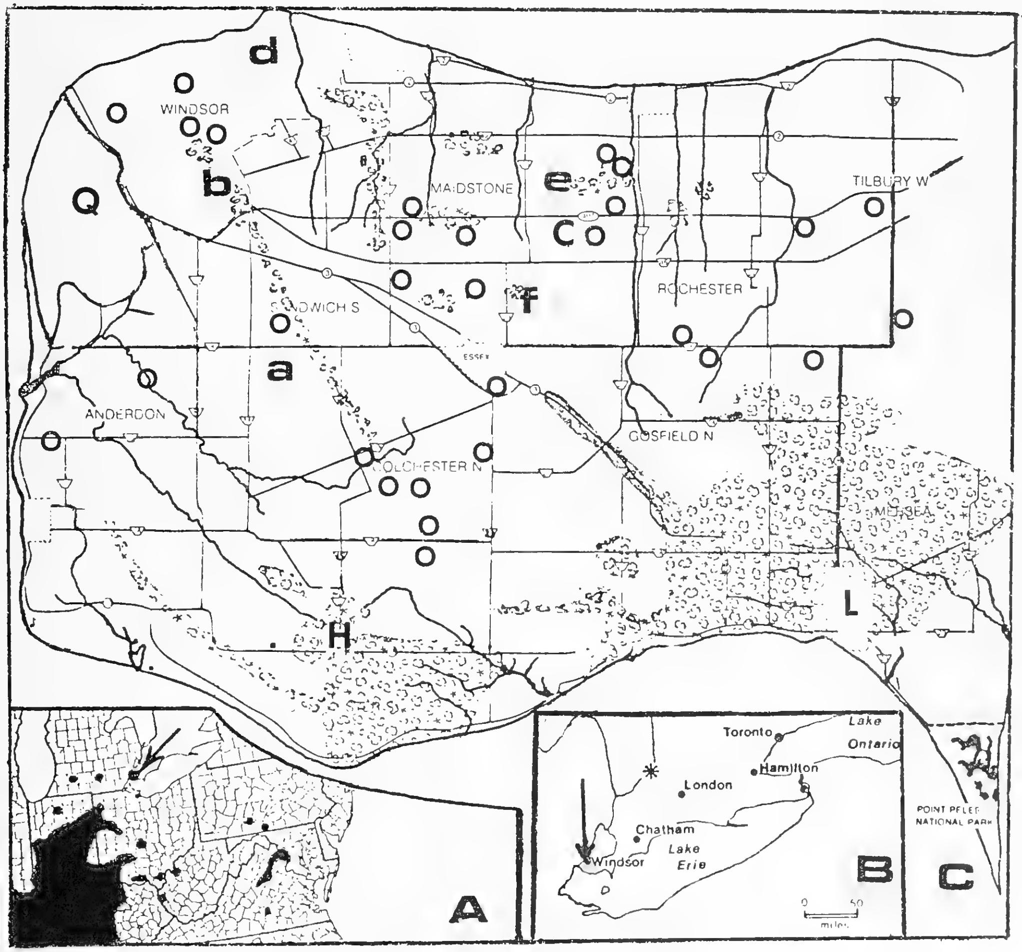

FIGURE 1. Shumard Oak (*Quercus shumardii*) distributions; 1A. Ohio, Indiana and southern Michigan (after Fowells 1965 and Little 1971); 1B. Essex and Kent Counties, from Windsor to Chatham, Ontario (after Waldron: Status Report) 1C. Locations of Shumard Oak collections at locations "a" to "f" and with circles denoting collections of hybrids with Shumard Oak on the bottomlands of Essex County. Forest pattern denotes presence of Red Oak (*Quercus rubra*). Q = Ojibway Prairie; H = Harrow and L = Leamington, Ontario.

Identification and Tree Associates

Shumard-like Oak trees resembling those described by Harlow and Harrar (1958) occur together with Pin Oak in all locations examined and also with Red Oak in several locations on better drained areas. Black Oak was not encountered at any of the Shumard Oak locations, although it is a frequent tree on xeric sites in Essex County. Scarlet Oak has not been positively identified in Ontario, but trees that resemble Scarlet Oak and/or Scarlet Oak x Black Oak hybrids are not uncommon at the Ojibway Prairie, Windsor, Ontario. Hill's Oak has not been reported for Essex County, although reported for the nearby Waterloo area by Ball (1981). Hill's Oak is considered by Overlease (1977) to be a northern expression of Scarlet Oak, and this similarity has been noted by Barnes and Wagner (1981), who provide illustrations and descriptions for these two species as they occur in Michigan. The close similarity between Scarlet Oak and Hill's Oak may also be reflected in the great variability and unusual leaf shapes of Pin Oak at Ojibway Park, possibly the result of introgression with Hill's Oak or Scarlet Oak. Although the Ojibway Prairie was one of the areas where no Shumard Oak could be located, its close proximity to the clay bottom lands with Pin Oak and Shumard-like Oak is a consideration in any specimen determination. The following comparative diagnosis should aid identification.

Shumard Oak. A tall, coarsely branching tree, about 25–35 metres in height, with shallowly furrowed bark; occurs in Essex County on wet-mesic clay plains.

LEAVES up to 20 cm, 7–9 lobed, *sinuses deep and relatively narrow, indented ¾ of the width of the leaf,* leaf surface lustrous; *secondary-bristle-tipped lobing.*

TERMINAL BUDS dark brown, usually 6.0 mm with faintly hairy scales.

ACORNS from 1.5 to 3.0 cm, as wide as long, tapering towards the apex, in shallow thick cup (diameter up to 2.5 cm, depth 0.8 cm) with tight scales, faintly hairy.

Red Oak. *Very similar to Shumard Oak,* but occurs on mesic to xeric sites. *Bark furrows wide and flat.*

LEAVES up to 20 cm, but *9–11 lobed, sinuses shallow and wide-V-shaped,* rarely indented to ⅔ of the width of the leaf, dull upper surface.

TERMINAL BUDS reddish brown, about 6.0 mm.

ACORNS from 1.7 to 2.5 cm, either of narrow-long type in deep bowl-shaped cup (diameter 1.5 cm, depth 0.8 cm), covering one half of acorn, or as wide as long with flat cup, (diameter 2.0 cm, depth 0.50 cm) with red-margined scale tips.

Pin Oak. A medium sized tree on wet sites, with sloping lower branches, horizontal middle branches and upward reaching upper branches.

LEAVES up to 15 cm, *mainly 5 (to 7) lobed, with slender petioles, sinuses deep* and wide, lower lobes often recurved, pale lustrous upper surface, hairless below with faint axillary tufts.

ACORNS up to 1.5 cm, as wide as high in flat cup (diameter 1.0 cm, depth 0.3 cm) with tight scales.

Associates of Shumard Oaks on Essex County bottomlands are Pin Oak, Bur Oak (*Q. macrocarpa*), Swampwhite Oak (*Q. bicolor*), Chinkapin Oak (*Q. muhlenbergii*) occasionally only, Shellbark Hickory (*Carya laciniosa*), Shagbark Hickory (*Carya ovata*), Bitternut Hickory (*Carya cordiformis*), Silver Maple (*Acer saccharinum*), Sycamore (*Platanus occidentalis*), Red Ash (*Fraxinus pennsylvanica*), Cottonwood (*Populus deltoides*) and White Elm (*Ulmus americana*) as the most frequent species encountered. Red Oak, White Oak (*Q. alba*) and Basswood (*Tilia americana*) are additional associates of Shumard Oak on slightly elevated areas covered by a sandy layer overlaying the clays.

Specimen Collections

About 59 samples were collected from 1980 to 1982 from Shumard-like Oaks, intermediates between Shumard and Pin Oak and intermediates between Shumard and Red Oak. Care was taken to take leaves from the middle section of crowns in order to exclude the juvenile type of leaves. Where possible, acorns were collected from the few fruiting trees. Collection locations are indicated on Figure 1C, by circles for intermediates of all types and by the letters a,b,c,d,e and f for leaves that closely resembled Shumard Oak. All collections were deposited at the herbarium of the Ojibway Nature Centre, Windsor, Ontario.

Locations of the collections were noted from topographic map series 1:50 000, Windsor sheet 40J/6, Belle River sheet 40J/7 Essex sheet 40J/2 and Amherstburg sheet 40J/3. These four maps cover the collection area of Shumard Oak in Essex County, Ontario. Essex County is located between 42° 00′N to 42° 20′N and 83° 10′W to 82° 30′W, or as indicated by the Universal Transverse Mercator Grid (UTM), zone 17T from 3250 to 3760 East and from 56510 to 46860 North. All collections are indicated by the last three digits East and the last three digits North of this UTM metric grid reference system. For example, the collection from Paquette Corners, Figure 1C, is marked as 400 709a, a shortened form of the UTM grid reference 3400 East 46709 North, with the letter "a" indicating tree "a" at that UTM grid reference point.

Shumard-like Oaks

Specimen that resemble Shumard Oak closely, with 9-lobed leaves, secondary bristle-tipped lobes and narrow but deep sinuses are located on Figure 1C,

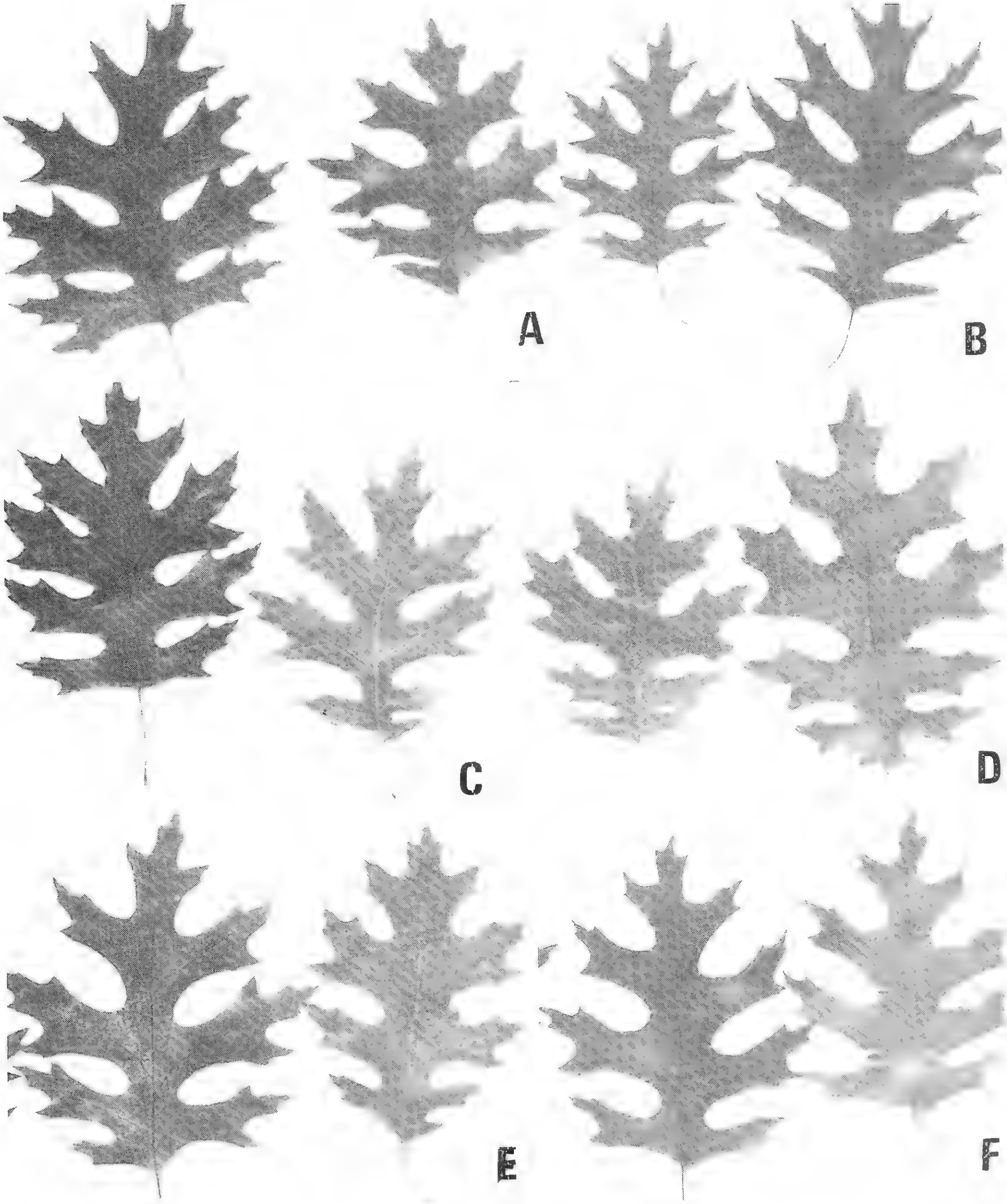

FIGURE 2. Samples of Shumard Oak leaves collected from locations "a" to "f" on Fig. 1C; 2A. Paquette Corners; 2B. Devonwood Conservation Area; 2C. Fynn Road at Highway 401, Maidstone Township; 2D. Schiller's Bush, Windsor, Ontario; 2E. Maidstone sanitary landfill; 2F. Maidstone Conservation Area. All figures x 3.

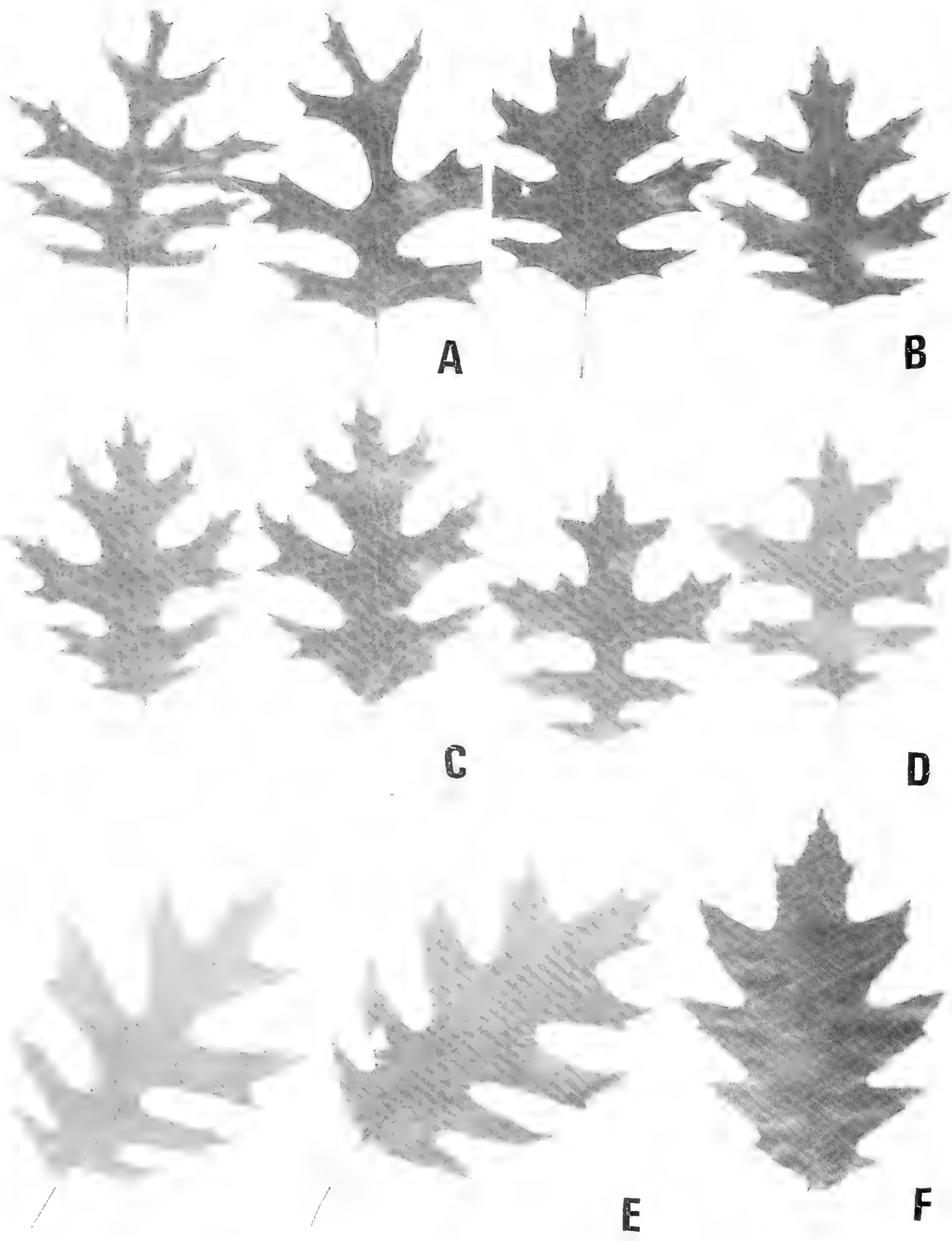

FIGURE 3. Leaves of Shumard Oak x Pin Oak (*Quercus palustris*) hybrids; 3A. Essex Civic Centre, woodlot; 3B. Askin Ave. 1225, Windsor, Ontario; 3C. Memorial Park, Windsor, Ontario; 3D. Gesto, Ontario, Colchester North Twp; 3E. Leaves of Shumard Oak x Red Oak at Devonwood Conservation Area; 3F. Red Oak leaf from West Hill, Ontario, for comparison. All figures x 3.

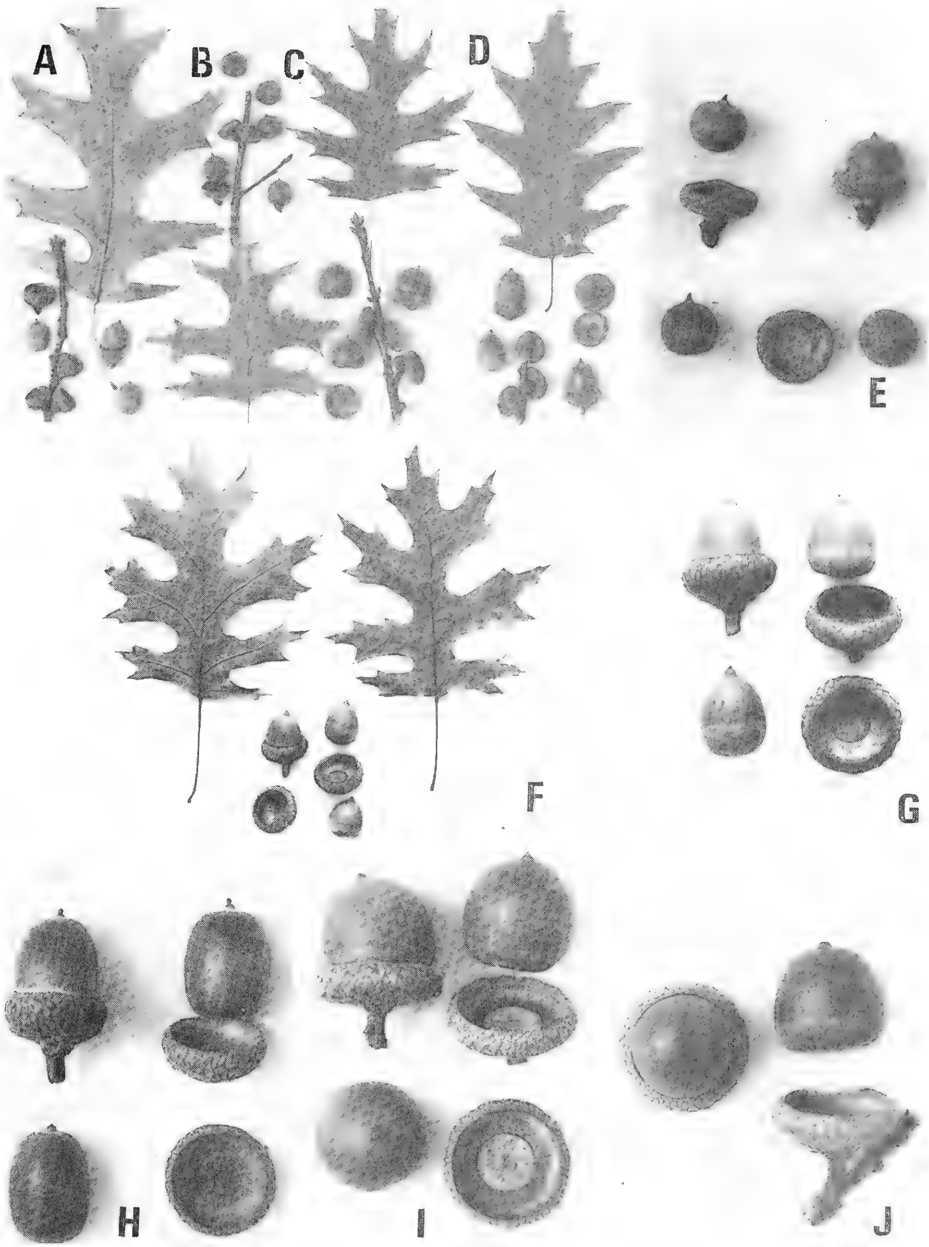

FIGURE 4. Comparison of acorns x 3; 4A. Black Oak (*Quercus velutina*) Ojibway Park; 4B. Pin Oak (*Quercus palustris*) Ojibway Park; 4C. Shumard Oak x Pin Oak, Devonshire Crescent, Windsor, Ontario; 4D. Red Oak, West Hill, Ontario; 4E. Acorns x 1 of Pin Oak (1 cm) Ojibway Park; 4F. Leaves and acorns of Shumard Oak, Division Road, Windsor, Ontario; 4G. Acorns as 4f. x 1, acorns (1½ cm); 4H. Acorns x 1 of Red Oak (2.5 cm) at Liberty and Victoria Ave., Windsor, Ontario; 4I. Acorns x 1 of Shumard Oak, collection 344 863d, at Devonshire Crescent, Windsor, Ontario; 4J. Acorns x 1 of Shumard Oak, collection 344 863a, Devonshire Crescent, Windsor, Ontario.

letters a,b,c,d,e, and f, and their illustrations are shown in Figure 2A to F, respectively. The Paquette Corner's tree (Figure 1C-a and Figure 2A, collection 400 709a) is a solitary large tree with coarse branching habit and buttressed trunk growing near a farm house.

The Devonwood Conservation Area tree, Figure 2B, collection 366 807b is one of half a dozen trees from which some additional collections (366 807a, c, and d) were made. All these trees resemble the Paquette Corners tree (Figure 2A) in leaf features. Many of these are stump sprouts that have grown up, apparently after removal of the original tree. Tree collection 366 807a, located at 1523 Division Road on a privately owned lot resembles the Paquette Corners tree closely in habit and measures 100 cm in diameter with a height of 20 m. This collection, 366 807a has 7-lobed leaves as illustrated in Figure 4F and G with typical acorns 1½ cm tall by 1 cm wide tapering towards the apex.

Trees at Fynn Road and Highway 401 (Figure 2C, collections 538 767b, and a,c,d, and e) all at the same location, resemble Shumard Oak in leaf, and tree habit, as well. A nearby tree at the Maidstone Conservation Area (post #2, collection 523 748a) also resembles Shumard Oak in leaf features (Figure 2C), having a diameter of about 125 cm, but the habit is more like Pin Oak.

The tree at Schiller's Bush, Windsor, (Figure 2D), collection 400 868a is a coarsely branching tree like Shumard Oak and several additional Shumard Oaks are located in this privately owned woodlot, which is slated for subdivision development.

A coarsely branching Shumard-like Oak is located immediately east and across the road from the Maidstone Sanitary Landfill, as illustrated in Figure 2E, collection 540 797a.

The Maidstone Conservation Area tree at post #15, Figure 2F, collection 523 748f has 9-lobed leaves, but lack the exaggerated secondary lobing of Shumard Oak; this tree grows near a small grove of Red Oak which grow on a sandy knoll. All these trees, located on Figure 1C, a,b,c,d,e and f and illustrated by leaf features in Figure 2A to F, amount to about only two dozen trees that in many ways resemble the description of standard Shumard Oak. All these trees were located (with the exception of the solitary tree at Paquette Corners) in habitats which contained Pin Oak and intermediates between Pin and Shumard Oak.

Intermediates With Pin Oak

Intermediates resembling Pin Oak are located in the woodlot east of the Essex Civic Centre, Essex. These trees feature 7–9 lobed leaves with some secondary lobing, but with very wide and deep sinuses as in Figure 3A, collection 498 690d. Other similar trees are located at the Devonwood Conservation Area (collectoin 366 807e and the Fogolar Furlan woodlot, Windsor, collection 361 830a).

At 1225 Askin Blvd., Windsor (Figure 3B, collection 304 846a) a second type of intermediate Pin x Shumard Oak leaf with 7 lobes is illustrated. This tree is coarsely branching, but resembles Pin Oak somewhat in bark and habit. Similar to this tree are intermediate oaks located at the highway 401 weigh scales (Maidstone Township) collection 459 779a,b,c,d, and e. Additional trees similar to the foregoing are at Memorial Park, Windsor (collection 350 840f), Maidstone Township (collection 486 769a), Canard River (collections 320 710a and b), Barrettville (collection 486 615a), Liberty at Victoria, Windsor (collection 344 812a and b), Maidstone Conservation Area (collections 523 748h, l,g, and b), Devonwood Conservation Area (collections 366 807b and g), and Essex Civic Centre woodlot (collection 498 690a).

Several trees at Memorial Park (Figure 3C, collections 350 840a and b) feature 7–9 lobed leaves with secondary lobing resembling Shumard Oak; these trees have the coarse wide spreading habit of Shumard Oak, but the acorns are intermediate between Pin and Shumard Oak in size and shape. Similar trees exist at Devonshire Crescent, Windsor (collections 348 863a and e) and at the Maidstone Conservation Area (collection 523 748c).

Intermediates between Pin and Shumard Oak, but with acorns that appear like over-sized Pin Oak acorns and 7–9 lobed leaves with less of the secondary lobing (Figure 4C, collection 348 863b) are located at Devonshire Crescent and Willistead Park, Windsor (collection 344 869a). The latter tree grows near four similar trees in Willistead Park, featuring straight trunks (about 60–140 cm in diameter), with Pin Oak-like branching and some of these trees consistently turn a wine red colour in the fall.

Different intermediates that resemble Pin Oak mostly are located at Gesto (Figure 3D, collections 450 655a and b). These trees show 7-lobed leaves with broad open sinuses and some tendency towards Shumard Oak secondary-type of lobing. The leaf shown in Figure 3D, should be compared with Pin Oak Figure 4B, from Ojibway Park which has distinctly 5–7 lobed leaves with some extra bristled secondary lobing but with very typical Pin Oak acorns (1 cm) as in Figure 4E.

Intermediates with Red Oak

Intermediates between Shumard Oak and Red Oak occurred less frequently during the survey of the bottomlands of Essex County. Such intermediates are shown in Figure 3E, collection 366 807h with two leaves of one tree shown in contrast to a Red Oak leaf from West Hill in Figure 3F. Such leaves show 9 lobes

with variable depth of the sinus and some secondary lobing as in Shumard Oak. This tree occurs near a Shumard-like Oak in the northeast corner of the Devonwood Conservation Area, together with a Red Oak. The leaves of Figure 3E should be compared to the leaf of Black Oak, Figure 4A, from Ojibway Park. Additional intermediates between Red and Shumard Oak are located at Devonshire Crescent, Windsor (collection 348 863a and d, with their acorns shown in Figure 4J and Figure 4I respectively). The acorns of Figure 4J, and 4I, are 2.5 cm tall by 2.0 cm wide, showing a taper towards the apex, resembling the acorn of Shumard Oak shown on page 358, or the broad type of Red Oak, page 354 in Harlow and Harrar (1958). For comparison see the narrow type of Red Oak acorn, shown in Figure 4H, Memorial Park, Windsor (collection 350 840d). Liberty and Victoria, Windsor (collection 344 812e), and Fynn Road at Highway #401 (collection 538 767d) are locations with trees that appear to be intermediates between Red and Shumard Oak, as well.

Discussion

Two of the larger trees in Essex County that resemble Shumard Oak closely, are located at Paquette Corners and Devonwood Conservation Area (1523 Division Road, Windsor). These two trees are among about two dozen trees that feature 9-lobed leaves with strong secondary lobing. Hybridization in the genus *Quercus* is common as the work by Cottam et al. (1982) indicates and many natural hybrids of this genus including Shumard Oak are listed by Fowells (1965). In Essex County, hybridization between Shumard and Pin Oak appear to have created a large number of intermediates with great variability in leaf and acorn morphology and tree habit. Because such trees often backcross to either parents, as for example Shingle Oak in Michigan (Wagner and Schoen 1976), many of these backcrosses may well be indistinguishable from either Pin or Shumard Oak. Such a hybrid complex between mainly Shumard and Pin Oak will require further verification.

Shumard Oak was inventoried as Red Oak in this County by the Ontario Ministry of Natural Resources until early 1984, when this fact was acknowledged by this Ministry. Heavy deforestation of Essex County, where less than 2% of the original forest cover remains, has resulted in the elimination of what may have been a reasonably large population of Shumard Oak. Because of resemblance in habit, number of leaf lobes (9), and acorn size, it is easily mistaken for Red Oak.

This Shumard Oak population is located at the same northern latitude as the few Shumard Oak locations mapped in southern Michigan. It could be considered as a relict species, part of a former extensive intrusion of southern *Erythrobalanus* oaks into Indiana, Ohio, southern Michigan and southern Ontario, in the same manner as the tallgrass prairie intrusion into southern Ontario as reported by Rogers (1966) and inventoried by P. D. Pratt[3] in 1979. From an ecological viewpoint Shumard Oaks in Essex County are important, because they occupy wet, clay bottomlands where Red Oak does not thrive. The species of these bottomlands match southern species listed for river floodplain and bottomlands in southern Michigan (Barnes and Wagner 1981), listed earlier (Identification and Tree Associates). For this reason the authors are attempting to establish seedlings in order to re-introduce offspring of this Shumard Oak population to the urban area of Windsor, Ontario. It is hoped that in this way Shumard Oaks will be able to replace those that will undoubtedly be lost through cutting on private woodlots. The best natural regeneration of Shumard Oak was observed to occur along the ditch along the Fynn Road and Highway 401 location. Further work on this species and its probable intermediates is underway.

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Winter Mortality of Dall Sheep, *Ovis dalli dalli*, in Kluane National Park, Yukon

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The Dall Sheep (*Ovis dalli dalli*) population of Sheep Mountain, Kluane National Park, declined from 241 in June 1981 to 180 in June 1982. Old animals (≥ 7 years) as well as new-born lambs were the population cohorts primarily affected. The winter of 1981/82 was one of the most severe on record, with below average temperatures and above average snowfall from January to May. The winter was also unusually calm, and snow covered vegetation normally grazed by sheep when winds swept the alpine ridges. Spring green-up was delayed by about 10 days. Superimposed on these severe weather conditions was increased pressure by predators, because of scarcity of alternate prey species.

Key Words: Winter mortality, Dall Sheep, *Ovis dalli dalli*, Kluane National Park, Yukon, population dynamics.

Large die-offs have been recorded for many ungulate species but few have been documented for Dall Sheep (*Ovis dalli dalli*). Murie (1944) referred to a number of years in Denali National Park, Alaska, in which many sheep died as a result of unusually severe winter conditions. Nichols and Smith (1977) recorded a 40% decline of a Dall Sheep population due to a harsh winter in the Kenai Peninsula, Alaska. The only major decline of a Dall Sheep population so far reported for Yukon Territory appears to have been caused by overhunting (Hoefs 1975).

Study Areas

The study area, "Sheep Mountain" is located adjacent to Kluane Lake, southwest Yukon Territory, Canada, in the centre of newly established Kluane National Park (Figure 1). Three vegetation zones have been described for the area: (1) the boreal forest zone, consisting mainly of White Spruce (*Picea glauca*) extending from the level of Kluane Lake (775 m) to an elevation of about 1200 m; (2) the sub-alpine shrub zone, composed mainly of Dwarf Birch (*Betula glandulosa*) and various willow species (*Salix* spp.), reaching an elevation of 1550 m on favourable sites; and (3) the alpine zone above 1550 m (Hoefs et al. 1975).

The bedrock of the area is made up of metamorphic and sedimentary deposits of Triassic, Permian and Cretaceous ages. The physiography was modified by three glacial periods (Muller 1967).

The Kluane Range lies in the rainshadow of the St. Elias Mountains and the climate is semi-arid and continental. Annual precipitation is usually less than 250 mm. Summer temperatures rarely reach 25° C, while winter temperatures of -40° C to -50° C are not unusual. The annual mean temperature is -2.5° C (Taylor-Barge 1969).

The local sheep population is characterized by a high density, short life expectancy, and a high frequency of various mandibular anomalies (Glaze et al. 1982; Hoefs 1975).

Methods

The Sheep Mountain population of Dall Sheep has been surveyed annually since 1969. Survey procedures are outlined by Hoefs (1975). The area has been regularly patrolled by staff of Kluane National Park since 1973, and predator activities and sheep mortalities have been routinely recorded.

When it became apparent that more than the usual number of sheep were dying during the 1981/82 winter, special efforts were made to search the mountain's slopes thoroughly in order to document the extent of this mortality. Vehicle and foot patrols of sheep winter ranges were made every day or two from January through May to check on sheep and/or predator activities. Information such as location of carcass, sex, age, time of death, presence of fetus in ewes, and evidence of predators or of a possible chase or fight was recorded whenever possible. In instances where the carcass was relatively fresh, tracks in the snow or soil could be used to interpret the events leading up to the animal's death, as well as the predator involved. General condition of the carcass was noted if possible, and femur marrow was examined in the field to determine the health of the animal at the time of death after methods described by Greer (1969). Animals were classed as being in good or poor condition, depending on whether their marrow was pinkish-white, firm and fatty or reddish, soft and gelatinous with little or no fat. Skulls were collected for assessment of horn growth characteristics; ages were determined using the horn annulus technique as described by Geist (1966) and Hemming (1969). Observations were continued into June in order to record late sea-

FIGURE 1. Map of southwestern Yukon showing Kluane National Park with study population's range.

son mortalities and to determine lambing success.

Weather information was obtained from the Kluane weather station operated by the Arctic Institute of North America and located about 5 km east of Sheep Mountain. Data on wind velocity and direction were obtained from Burwash Landing airport, located about 50 km to the northwest.

Results

Population estimates based on reported ground and aerial surveys indicate the sheep herd declined from 241 in June 1981, to 180 in June 1982 (Table 1) —a reduction of 25.3%. The results from two other sheep surveys conducted within Kluane National Park revealed declines of 40.1% in the Donjek Range between 1981 and 1982 (Sundbo, unpublished Parks Canada report), and 30.9% between 1980 and 1982 in the Mt. Vulcan population (Burles, unpublished Parks Canada report). Sheep surveys conducted in other parts of the Yukon also revealed that declines had occurred (Hoefs unpublished data). These widespread declines suggested the influence of a universal factor such as weather.

Weather records obtained from the Kluane Lake weather station indicate that conditions during summer and early winter of 1981 were near the mean for the station (9–12 years of data), but were unusually severe during late winter and spring of 1982. During the 1982 growing season (May to early August), temperatures were near normal (Table 3), but less than average rain fell (Table 4). Temperatures and precipitation were near normal for autumn 1981, except for more precipitation during September, but from January to May 1982 inclusive, temperatures were significantly colder ($\chi^2 = 16.6$, d.f. = 4, $p > 0.995$). The cooler temperatures in April and May

TABLE 1. Estimated Dall Sheep population for June 1981 and 1982, Sheep Mountain, Yukon Territory, and calculated declines between 1981 and 1982.

Age class	Rams ⩾ 3 years	Ewes ⩾ 3 years	Young of 1979	Young of 1980	Young of 1981	Young of 1982	Total
June 1981	79	86	24	29	23		241
June 1982	65	68	*	26	17	4	180
Decline	-14	-18	-24*	-3	-6	+4	-61

*The 2-year old age class present in 1981 would be counted with adult animals in the 1982 population counts so that adult members actually decline by a further 24 animals.

caused a noticeable delay in spring green-up, as established through phenological observations (Hoefs 1979). Precipitation rates were above average for the December to April period, also.

The Kluane Lake weather station does not record wind so records were obtained from Burwash Landing airport. At Burwash, the prevailing wind is from the southeast, with occasional winds from the northwest. Relevant in this context are winds from the southeast, since they blow snow from the grassy slopes of Sheep Mountain, thereby exposing forage for the sheep. Wind records indicate that the winter of 1981/82 was exceptionally calm. The number of days from January to May inclusive, during which the wind blew at greater than 16 knots from the southeast, was significantly fewer than the 15-year mean value (χ^2 = 14.5, d.f. = 4, p > 0.95) (Table 5). The result of this lack of wind was that by March Sheep Mountain was blanketed by about 30 cm of snow.

We can calculate from Table 1 that 56 adults, three young of 1980 and six young of 1981 were removed from the 1981 population, while only four lambs were added to the population in 1982. The number of adults removed was estimated by adding the number of rams, ewes and two-year olds (young of 1978) present in 1981, and subtracting the number of rams and ewes (which would include the young of 1979) present in the 1982 population. Assuming that the sex ratio of two-year olds is equal, then the decline in ram numbers would be the observed decline (14) plus 12 or 26, and the decline in ewe numbers would be the observed decline (18) plus 12 or 30.

Forty-six sheep mortalities were recorded during the winter and spring of 1981/82, of which 38 were adults (15 rams, 17 ewes, and 6 unknown sex), three were young of 1980 (1 ram, 2 ewes), five were young of 1981 (Table 2). As well, four new-born lambs are known to have died, and at least two others disappeared shortly after birth. Four pregnant ewes also died, which further reduced the 1982 lamb crop. Differences between the estimated decline (Table 1) and observed mortalities (Table 2) are primarily in the adult classes. Skulls of young animals and ewes tend to deteriorate quickly and are harder to find, which could account for some of the differences. Some skulls, particularly those of rams, may have been removed by visitors. The possibility of emigration of some animals cannot be ruled out, either.

Dates of death and health of the animal could be accurately determined for only 25 sheep. One sheep died during November, three during January, two during February and four during March; bone marrow indicated that they were all relatively healthy at the time of death. Two sheep that died during April, and seven of nine sheep that died during May, showed evidence of severe malnutrition. Four new-born lambs are known to have died during May and June but their relative health could not be determined.

Cause of death could be established for 24 sheep. The 10 sheep that died between November and March were all killed by Coyotes (*Canis latrans*). During April and May Coyotes killed two sheep, while Wolves (*Canis lupus*) killed four, including one new-born lamb. These predators may have been responsi-

TABLE 2. Mortality by sex and age class of Dall Sheep, observed during the winter of 1981-82, Sheep Mountain, Yukon Territory.

Age (years)	0+	1+	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+	Total
Rams		1					2		1	3	8		1	16
Ewes		2					1	4	1	4		3	4	19
Sex Unknown	5	←				6 Adults							→	11
Total	5	3	←			38							→	46

TABLE 3. Mean monthly temperatures for Kluane weather station, Yukon Territory as compared with mean monthly temperatures from April 1981 to May 1982. (Means are based on 9-12 years of data collected between 1969 and 1982).

Month	Mean	1981-82	Differences
April	-1.2	-3.5	-2.3
May	5.4	7.6	+2.2
June	9.8	9.1	-0.7
July	11.4	13.1	+1.7
August	11.3	11.7	+0.4
September	6.0	—	—
October	-0.3	0.6	+0.9
November	-9.0	-7.5	+1.7
December	-18.4	-18.1	+0.3
January	-19.3	-29.4	-10.1
February	-15.3	-20.9	-5.6
March	-10.0	-11.8	-1.8
April	-1.2	-4.4	-2.2
May	5.4	3.9	-1.5

ble for a number of other mortalities but clear evidence of a chase or fight was frequently removed by trampling of the area, and the rapid and complete utilization of the carcass. In these cases, the act of predation could not be separated from scavenging activity. In June, a Golden Eagle (*Aquila chrysaetos*) was observed to take a new-born lamb (Nette et al. 1984).

Predators were numerous in the Sheep Mountain area during the winter of 1981/82; Coyotes were seen on sheep ranges almost daily, and up to seven were seen at one time. A pack of four or five wolves also visited the area periodically, and are known to have denned in the area. At least three Golden Eagle nests on Sheep Mountain were active during the spring of 1982, as well.

Six sheep were found to have died as a result of accidents. The remains of four sheep were found in an avalanche and two apparently fell off cliffs. The latter two sheep were emaciated and suffering from severe malnutrition, one of them was observed and photographed (Figure 2) in early May, a few days before her accident. At this time she was bony-looking, slow-moving and spent little time feeding. She was later found to be carrying a fetus. One intact, emaciated carcass of a pregnant ewe was also found in a resting position during May, the victim of extreme malnutrition.

Discussion and Conclusion

We interpret the decline of 25.3% in the Sheep Mountain Dall Sheep population to be the result of an unusual coincidence of a number of factors. These factors include a high density sheep population depending on a winter range with below average forage production; a severe calm winter with long cold periods and deep snow taxing the energy reserves of the sheep and the decreasing availability of forage; a delayed green-up slowing the recovery of sheep, and lastly unusual high predator pressure because of lack of alternate prey species. We will briefly discuss each of these contributing factors.

The population size of 241 in June 1981 exceeded the 12-year mean level of 226 (Hoefs and Bayer, 1983). Forage production on the winter range is correlated to

TABLE 4. Mean monthly precipitation (mm) for Kluane weather station, Yukon Territory, as compared with precipitation from April 1981 to May 1982. Figures in parentheses refer to the amount of snow that fell during that month (in cm). (Means are based on 9-12 years of data collected between 1969 and 1982.)

Month	Mean Precipitation (mm) (Mean snow fall in cm)	Precipitation (mm) 1981-82 (Snowfall in cm)	Differences mm (cm)
April	7.0 (7.0)	13.0 (13.0)	+6 (+6)
May	10.6 (6.0)	8.2	-2.4 (6.0)
June	29.9	37.2	+7.3
July	41.9	33.2	-8.7
August	40.1	26.9	-13.2
September	23.0 (1.5)	(3.5)	+26.3
October	17.7 (17.7)		
November	21.6 (21.6)	17.4 (14.8)	-4.2 (-6.8)
December	11.7 (11.7)	16.4 (16.4)	+4.7 (+4.7)
January	8.1 (8.1)	2.0 (2.0)	-6.1 (-6.1)
February	8.8 (8.8)	16.8 (16.8)	+8.0 (+8.0)
March	5.7 (5.7)	12.4 (12.4)	+6.7 (+6.7)
April	7.0 (7.0)	9.2 (9.2)	+2.2 (+2.2)
May	10.6 (6.0)		

FIGURE 2. Emaciated ewe observed on the lower slopes of Sheep Mountain, Yukon Territory in early May 1982. This sheep was found dead at the base of a nearby cliff on 11 May, apparently the result of a fall. (D. Burles).

rainfall during the growing season (Hoefs 1984). The summer of 1981 was dry and warm (Tables 3 and 4) and forage production was correspondingly low. In years of population peaks a good correlation was documented between winter forage production, over-winter survival of lambs and lambs born the following spring (Hoefs 1984). Therefore, these two factors by themselves, high population density and low winter range forage production, will already account for a low over-winter survival rate of lambs and a low lamb crop in spring 1982.

The unusual severe winter 1981/82 compounded the problems. The long cold periods experienced from January through April constituted a considerable energy drain on the sheep. Additional energy was required to dig feeding craters in the 30 cm of snow that had accumulated on the winter range by March because of calm conditions. Detailed feeding observations carried out in the 1969–1972 period had revealed that over 50% of the winter feeding was done on snow-free areas, and less than 12% of all foraging took place in snow depths exceeding 10 cm (Hoefs and Cowan 1979).

The delay in spring green-up of about 10 days postponed the initiation of recovery of the sheep population, whose members had by May become extremely emaciated. Most sheep died during May.

Analysis of the causes of death revealed that 70.8%

TABLE 5. Mean numbers of days per month that the wind blew greater than 16 knots from the southeast and northwest at Burwash Landing Airport, for the period 1966–81, and 1981–82.

	Number of Days					
	15 year mean		1981-82		Differences	
Month	SE	NW	SE	NW	SE	NW
October	14.7	1.3	9	3	–5.7	+1.7
November	9.4	1.5	11	1	+1.6	–0.5
December	6.5	1.7	7	0	+0.5	–1.7
January	5.1	1.7	1	2	–4.1	+0.3
February	7.4	1.7	0	6	–7.4	+4.3
March	9.9	1.7	7	2	–2.9	+0.3
April	15.1	1.9	13	3	–2.1	+1.1
May	15.4	2.0	11	1	–4.4	–1.0

of sheep mortalities could be attributed to predation, mainly by coyotes, but also wolves and golden eagle. This pressure from predators was at least in part, a reaction to the vulnerable state that the sheep found themselves in, but also due to the scarcity of alternate prey sources. The Varying Hare (*Lepus americanus*) population crashed during the winter of 1981/82 as did Willow Ptarmigan (*Lagopus lagopus*) numbers (D. Mossop, ornithologist, Yukon Wildlife Branch, personal communication). Small mammals like Arctic Ground Squirrel (*Spermophilus parryii*) were also scarce in spring 1982.

The very young and the old are usually the age cohorts most severely affected by winter mortality (Barnett 1982; Clutton-Brock and Albon 1982; Reimers 1982), and observations on Sheep Mountain support these earlier records. The expected contribution to this population's annual death rate, based on the period 1969–1980, for the 9–13-year age classes is 35.8%, but during the winter of 1981/82 it amounted to 62.7%. No reliable information on early mortality of new-born lambs is available, but at least 10 were born and only four survived into June. At least four pregnant ewes are known to have died, thus reducing the potential lamb crop, but there were probably more than 10 lambs born. The 60% mortality rate of new-born lambs for 1982 is thus a minimum figure but it is much higher than the 19% average mortality rate determined for three previous years: 1971, 1972, 1976 (Hoefs and Bayer 1983).

Annual surveys of other sheep populations in southwest Yukon indicate that similar die-offs have occurred elsewhere. Thirty percent declines in total numbers were recorded for two other survey areas in Kluane National Park (Burles 1982 unpublished report to Parks Canada; Morrison, 1982 unpublished report to Parks Canada); similar declines were reported for some populations in other parts of the Yukon (Hoefs, unpublished data). The winter 1981/82 has been the worst on record in relation to wildlife mortalities in the Yukon. However, it has to be kept in mind, that detailed population monitoring here only started about 15 years ago.

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Additions to the Vascular Plant Flora of Bylot Island, Northwest Territories

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Cody, W. J., G. W. Scotter, and S. C. Zoltai. 1984. Additions to the vascular plant flora of Bylot Island, Northwest Territories. Canadian Field-Naturalist 98(4): 485–488.

Twenty-six species are added to the known flora of Bylot Island as a result of field surveys of 16 localities in 1982. Mountainous terrain produces a strongly vertical zonation of the vegetation; low arctic tundra is common at lower elevations, polar semi-desert communities dominate the hills and polar desert vegetation is encountered at high elevations.

Key Words: Vascular Plants, Bylot Island, Northwest Territories.

The vascular plant flora of Bylot Island has been reported by Drury (1962) and Porsild (1964). A natural resource survey by the Canadian Wildlife Service and Canadian Forestry Service, sponsored by Parks Canada, during 1982, added 26 taxa to the known vascular plant flora. The purpose of this paper is to record these additions.

A brief description of Bylot Island and its physiography, geology, climate and vegetation follows:

Bylot Island (Figure 1) is about 10,000 km^2 in area, about 185 km long from northwest to southeast, and about 100 km across at its widest point. It is separated from Baffin Island by the waters of Pond Inlet, Eclipse Sound, and Navy Board Inlet. The central two-thirds is mountainous and covered with icefields through which nearly a hundred peaks and ridges rise. From the borders of the icefields, 60 or more large glaciers flow outward in all directions. The only extensive lowlands are on the southwest and northwest coasts. These lowlands are generally below 350 m asl, although a few hills do rise above this level. The surface materials are sandy loam till, marine sand and silt, and bedrock rubble. Peaty wetlands are restricted to this physiographic unit. Several moderately sized streams, originating from glaciers, cross these lowlands. Many of these streams are extensively braided.

The geological provinces of the Bylot Island region have been described by Thorsteinsson and Tozer (1970), the physiography by Bostock (1970), and the geology by Blackadar (1970) and Jackson and Davidson (1975). Glacial geology has been studied in detail by Klassen (1982).

The area falls within Climatic Region IV as recognized by Maxwell (1981). Of primary importance is the high degree of cyclonic activity that influences most of the region. Another striking feature is the mountainous terrain which exists in much of the island. This terrain exerts an important influence on the local precipitation totals which are the highest among the arctic islands. Precipitation results primarily from the abrupt uplift of moisture-laden, onshore winds on the rugged coastal slopes. Although precipitation records are not available for Bylot Island, Baffin Island at Pond Inlet has a mean annual snowfall of 101.7 mm. Higher totals should be expected along the exposed northern coast of Bylot Island where adiabatic winds deposit appreciable amounts of precipitation.

Winter, a season of persistent rather than extreme cold, is characterized by strong temperature gradients between marine and land areas as cold air is warmed during its passage over open water areas. The lowest mean temperatures occur in February although the coldest winter temperatures may occur in any month from December to March. Temperature gradients begin to weaken by early May and the onset of summer (mean daily temperature greater than 0° C) occurs between 20 May and 15 June. The mean minimum temperature is above 0° C only during July and August. The frost-free period averages 15 days. The island is subject to potentially continuous daylight from early May to early August, but marine influences result in considerable seasonal cloud cover which severely limits available sunlight.

Permafrost underlies all land surfaces. The thickness of the frozen layer is not known, but is likely to be several hundred meters. The ice content of the permafrost is generally low because of the dominance of bare bedrock and coarse textured soils. Ice-rich permafrost was encountered in peaty lowlands where abundant moisture and finer textured soils occur.

The vegetation of the area strongly reflects a vertical zonation caused by the mountainous terrain. Low arctic tundra is common on the low-lying areas, while

polar semi-desert communities dominate the hills. At high elevations, polar desert vegetation type is encountered. The common tundra types include the low shrub-herb, with willow-grass and heath-herb subtypes; the shrub-sedge type; the wetland meadow type, with sedge-moss and *Eriophorum*-grass subtypes. Vegetation associations are given by Drury (1962). The polar semi-deserts are characterized by dwarf shrub barrens, with *Dryas* barren and *Saxifraga-Papaver* barren subtypes. Crustose lichen barrens are common in the polar desert uplands.

In the list of additions to the vascular plant flora which follows, the voucher numbers are those of Scotter and Zoltai. Latitudes, longitudes and elevations in meters above sea level (asl) of the collection sites from which specimens are cited in this paper (given in parentheses after voucher number) are:

1. 73°43′N, 80°01′W, 67m
3. 73°24′N, 80°43′W, 50m
4. 73°09′N, 80°02′W, 15 – 60m
5. 73°03′N, 80°07′W, 60m
7. 72°47′N, 79°31′W, 0 – 40m
8. 73°00′N, 79°15′W, 450m
10. 72°51′N, 76°06′W, 10m
11. 72°57′N, 78°23′W, 215m
12. 72°54′N, 78°08′W, 150m
14. 72°56′N, 79°17′W, 155m

The first set of voucher specimens have been deposited in the herbarium of the Biosystematics Research Institute, Agriculture Canada, Ottawa (DAO). Some duplicates have been deposited in the herbarium of the Canadian Forestry Service, Edmonton (CAFB). Identifications were by Cody.

LYCOPODIACEAE

Lycopodium selago L., Mountain Club-Moss, *67066*(3), *67210*(8) — This is a circumpolar, wide-ranging, high-arctic species, which on Bylot Island is well within its range.

GRAMINEAE

Deschampsia brevifolia R.Br., Hairgrass, *67160*(7) — This is a circumpolar, arctic-alpine species which according to the map in Porsild and Cody (1980), is widespread in the Canadian Arctic Archipelago, but known on the adjacent Baffin Island only from a single site in the northern part.

Poa alpigena (Fr.) Lindm. var. *alpigena*, Blue Grass, *67178*(7), *67244*(14) — According to the maps in Porsild and Cody (1980), most of the records for *P. alpigena* in the Canadian Arctic Archipelago belong to the viviparous var. *colpodea*. With the exception of a site on western Ellesmere Island, the collections reported here are the northernmost in the Archipelago for var. *alpigena*.

CYPERACEAE

Carex amblyorhyncha Krecz., Sedge, *67177*(7) — With the exception of a single collection by Beschel from Axel Heiberg Island, the specimen cited here is the northernmost yet reported from the Canadian Arctic Archipelago.

Carex atrofusca Schk., Sedge, *67078B*(3) — This circumpolar high-arctic species is well within its range on Bylot Island.

Carex nardina Fr. var. *atriceps* Kuk., Sedge, *67073*(3) — This is an Amphi-Atlantic species which is well within its range on Bylot Island.

Carex scirpoidea Michx., Sedge, *67081*(3), *67207*(7) — This is a wide-ranging North American species which is almost at its northern limit of distribution in the Canadian Arctic Archipelago on Bylot Island.

Carex subspathacea Wormskj., Sedge, *67187*(7) — This is a circumpolar species which is almost at its northern limit in the Canadian Arctic Archipelago on Bylot Island.

Carex ursina Dew., Sedge, *67184*(7) — This is a circumpolar high-arctic species which is well within its limits of range on Bylot Island.

Eriophorum callitrix Cham., Cotton Grass, *67085*(3) — This is the northernmost collection yet made in the Canadian Arctic Archipelago. There is, however, a nearby site at Pond Inlet on northern Baffin Island.

Eriophorum triste (Th. Fr.) Hadac & Love, Cotton Grass, *67080*(3) — This is a circumpolar species which is well within its limits of range on Bylot Island.

CARYOPHYLLACEAE

Cerastium regelii Ostf., *67020*(1) — This circumpolar, high-arctic species barely reaches the Canadian mainland on Melville and Tuktoyaktuk peninsulas. Porsild and Cody (1980) indicate only three sites on nearby Baffin Island, but the species is widespread in the Archipelago.

Melandrium affine J. Vahl, Bladder-Campion, *67109*(4), *67214*(8) — Another circumpolar arctic-alpine species which would certainly have been expected to be found on Bylot Island.

Melandrium triflorum (R.Br.) J. Vahl, Bladder-Campion, *67086*(3), *67112*(4), *67235*(12) — This is an endemic species of northern E and W Greenland (from whence there are many collections) and the northernmost islands of the Canadian Arctic Archipelago. The map in Porsild (1964) indicates but a single collection on the east side of Baffin Island southeast of the sites reported here.

Minuartia biflora (L.) Schinzl. & Thell., Sandwort, *67090*(3) — This circumpolar low-arctic species is, with the exception of a single site on Axel Heiberg Island, the northernmost yet reported for the Cana-

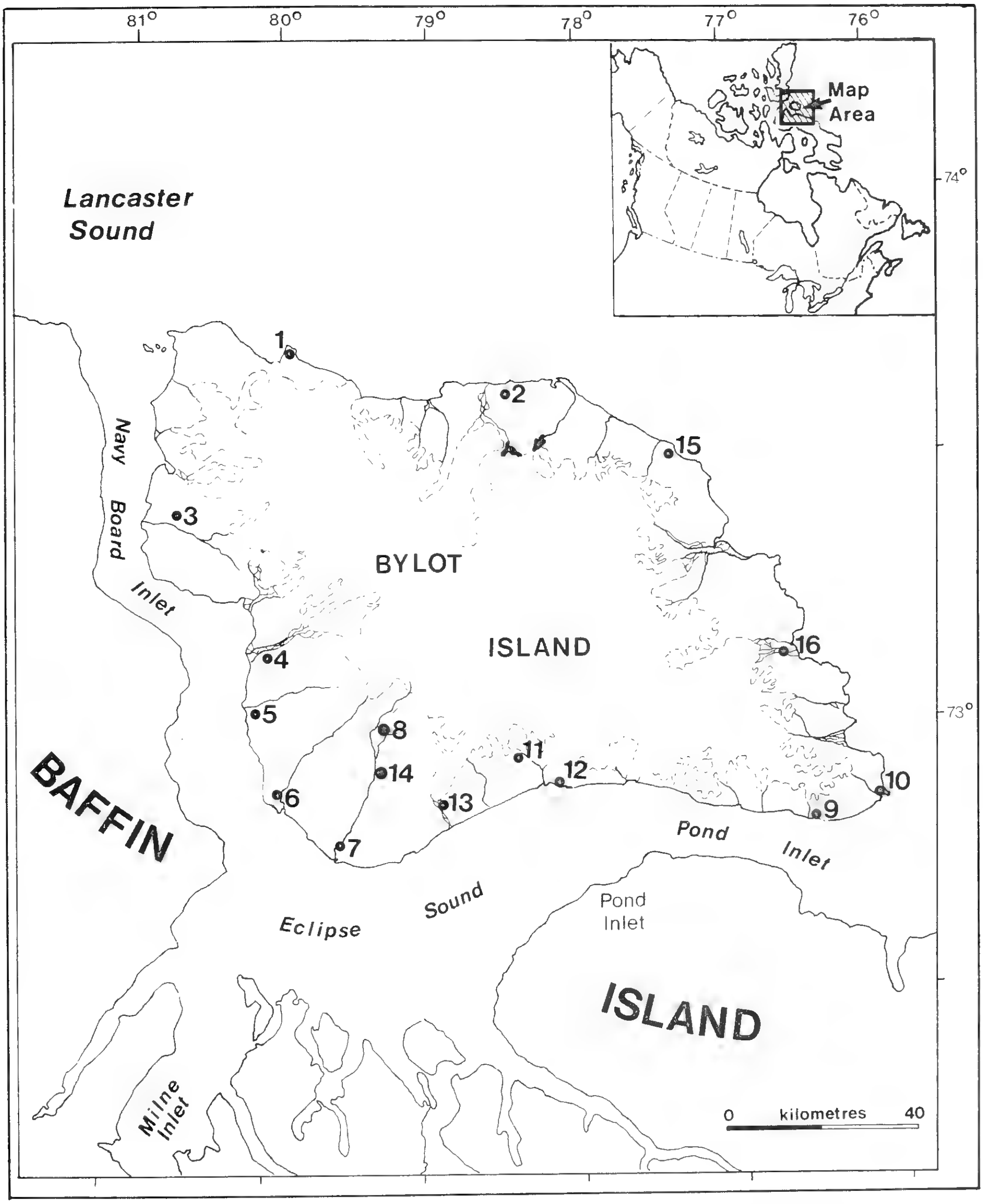

FIGURE 1. Map of Bylot Island depicting locations of collection sites.

dian Arctic Archipelago. It does, however, occur further north in both E and W Greenland.

Stellaria crassipes Hult., Chickweed, *67205*(7) — This is an Amphi-Atlantic taxon which is well within its range on Bylot Island.

Stellaria laeta Richards., Chickweed, *67096*(3), *67108*, *67134*(4), *67222*, *67223*(10) — A North American, arctic taxon which was certainly to be expected on Bylot Island.

RANUNCULACEAE

Ranunculus pygmalus Wahlenb., Dwarf Buttercup, *67135b*(4) — This is a circumpolar arctic-alpine species which is within its known range on Bylot Island.

CRUCIFERAE

Cardamine pratensis L. var. *angustifolia* Hook., Bitter Cress, *67183*(7) — This specimen is sterile, like many others of the species collected in the far north. It is well within its expected range on Bylot Island.

SAXIFRAGACEAE

Saxifraga tenuis Sm., Saxifrage, *67151A*(5) — This is an Amphi-Atlantic, arctic species which is within its known range on Bylot Island.

LEGUMINOSAE

Oxytropis arctobia Bunge, *67176*(7) — This species is at its northeastern known limit of distribution on Bylot Island. It is an endemic of the southern islands of the Canadian Arctic Archipelago and northern Canadian mainland.

HALORAGACEAE

Hippuris vulgaris L., Mare's-Tail, *67117*(4) — The map in Porsild and Cody (1980) depicts other far northern Canadian Arctic Archipelago sites on northern Baffin Island and the Fosheim Peninsula, Ellesmere Island. Additional northern collections are: Ellesmere Island at Hazen Lake, *Savile 4646, Maher 130* and *Kershaw s.n.*; Eureka, *Bruggeman 657, Scotter & Zoltai 45383*; and Devon Island, *Barrett 333* (all DAO).

PYROLACEAE

Pyrola grandiflora Radius, Large-flowered Wintergreen, *67110*(4), *67227*(11) — This is a wide-ranging circumpolar species that is near its northern known limit of distribution at Bylot Island, but is known from sites on Devon and southern Ellesmere islands.

COMPOSITAE

Chrysanthemum integrifolium Richards., *67095*(3) — This is a wide-ranging, North American, arctic-alpine species which is near its northern limit of continuous distribution at Bylot Island, but which is also known from SE Devon Island and north central Ellesmere Island.

Crepis nana Richards., Hawk's Beard, *67237*(12) — This arctic-alpine species which occurs from eastern Asia across North America to Newfoundland, is apparently at its northeastern limit of range on Bylot Island.

Taraxacum hyparcticum Dahlst., Dandelion, *67097*(3), *67216*(10) — This is an endemic of NW Greenland and the Canadian Arctic Archipelago which is within its expected range on Bylot Island.

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Notes

Summer Food Habits of Voles, *Clethrionomys rutilus* and *Microtus pennsylvanicus*, on the Kenai Peninsula, Alaska

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Bangs, Edward E. 1984. Summer food habits of voles, *Clethrionomys rutilus* and *Microtus pennsylvanicus*, on the Kenai Peninsula, Alaska. Canadian Field-Naturalist 98(4): 489–492.

Food habits of Northern Red-backed voles (*Clethrionomys rutilus*) and Meadow Voles (*Microtus pennsylvanicus*), captured on the Kenai National Wildlife Refuge in 1977, were examined by microhistological techniques. Red-backed Voles ate epigeous and hypogeous fungi, berries, and lichens while Meadow Voles ate primarily grass and hypogeous fungi. Red-backed Voles, captured in recently disturbed sites, utilized the same foods but in different proportions as voles captured in undisturbed sites.

Key Words: Northern Red-backed Voles, *Clethrionomys rutilus,* Meadow Vole, *Microtus pennsylvanicus,* food habits, histological.

Food habits of small mammals in Alaska have received little attention until recently (West 1982). As part of a study on the effects of habitat disturbance on small mammal populations on the Kenai Peninsula, Alaska (Bangs 1979), I documented the summer food habits of Northern Red-back Voles (*Clethrionomys rutilus*) and Meadow Voles (*Microtus pennsylvanicus*) using microhistological techniques. Microtine food habits are of interest to wildland managers, since rodent damage can be an important economic consideration in reforestation programs (Pank 1974), and rodent dispersal of fungi spores is important in promoting the symbiotic relationships between mycorrhizal fungi and higher plants (Maser et al. 1978).

Study Sites

Study sites were located on the Kenai National Wildlife Refuge in south-central Alaska. Overstory species at all sites were White Spruce, (*Picea glauca*), Black Spruce (*Picea marina*), Paper Birch, (*Betula papyrifera*), and aspen, (*Populus tremuloides*). Understory vegetation is dominated by Lowbush Cranberry, (*Vaccinium vitus-idaea*), moss (*Sphagnum* spp.), and lichens, (*Peltigera* spp. and *Cladonia* spp.). Common species also include willow, (*Salix* spp.), Bunchberry, (*Cornus canadensis*), grass, primarily (*Calamagrostis canadensis*), and various forbs and epigeous fungi, (mushrooms).

Voles were collected from six lowland boreal forest stands representing three paired habitat types: 1) 30-year old Black Spruce regrowth, 2) 30-year old Black Spruce-Paper Birch regrowth, and 3) 80–100-year old mature Paper Birch-White Spruce stand. Three stands in each habitat were mechanically treated in the winter of 1975 by three crushers to provide browse for moose, and three were untreated. Winter tree crushing initially affected overstory species by knocking down, and crushing, standing woody vegetation. Since the ground was frozen during treatment, understory species were affected by the loss of shade and change in microclimate. Habitat types were lumped into disturbed and undisturbed sites for food habits analysis. Understory vegetation was similar in both sites, although mechanically-disturbed sites had fewer berries, mosses, lichens, and mushrooms, and more shrubs, grass, and debris than undisturbed sites (Bangs 1979), a situation similar to that reported by Martell (1981) in Canadian selectively cut spruce stands. Red-backed Voles and Masked Shrews (*Sorex cinereus*) dominated the small mammal community regardless of stand age. Densities of Red-back Voles were positively correlated to protective cover in the form of aerial debris (Bangs 1979).

Methods

Northern Red-backed Voles were captured in modified snap traps (Bangs 1981) during July, August, and September of 1977. Disturbed and undisturbed sites were trapped simultaneously during four separate trapping periods totaling 5760 trap nights. One hundred thirteen Red-backed Voles, 131 Masked Shrews, 11 Dusky Shrews (*Sorex monticolus*), 29 Meadow Voles, and 1 Bog Lemming (*Synaptomys borealis*) were captured in disturbed sites. One

hundred fifty eight Red-backed Voles, 118 Masked Shrews, 3 Dusky Shrews, 4 Pygmy Shrews (*Sorex hoyi*), 1 Meadow Vole, and 2 Bog Lemmings were captured in undisturbed habitats.

A sample of 113 Red-backed Voles, 45 from disturbed and 68 from undisturbed sites, and 19 Meadow Voles, all from disturbed sites, were frozen for approximately four months before their stomachs were removed and examined. A sample of the stomach contents from each vole was prepared and permanently mounted on a microscopic slide, using standard techniques for food habits analysis (Dusi 1949; Williams 1962). Twenty observations (fields of view) per slide were viewed under a 100x compound microscope to determine the presence or absence of food items. Each observation was randomly selected with no repeats. When a field of view did not contain plant fragments, it was disregarded (Williams 1962). If material was present, but unidentifiable, it was so recorded. Approximately 15% of the fields of view contained all unidentifiable material. An average of 1.14 food types were identified in each of the 2640 fields of view examined. It was assumed that the relative occurrence of a food type on the slide was proportional to its volume in the diet (Sparks and Malecheck 1968).

Results and Discussion

Food habits of Red-backed Voles and Meadow Voles were different as also reported by Getz (1961) and Whitney (1976) (Table 1). Red-backed Voles fed on fruits, fungus, and succulent green plants (Schloyer 1977, Martell 1981, Merritt and Merritt 1978), while Meadow Voles fed on grass (Zimmerman 1965).

Stomach analysis indicated that Red-backed Voles on the Kenai Peninsula primarily ate fungi, berries, and lichens rather than succulent green plants (Table 1). The occurrence of the hypogeous fungus (*Endogone fascilulata*) in the diet remained constant throughout the summer. *Endogone* is reportedly an important small mammal food in North America (Bakerspigel 1956; Maser et al. 1978, and Schloyer 1977) and was an important part in the diet of voles on the refuge. The fruiting bodies of other epigeous fungi species (mushrooms) were generally not available in July or early August, and were absent in the diet at that time. As mushrooms became available later in the summer, they were used at an increasing rate by Red-backed Voles, as Martell (1981) also reported in Canada.

Cranberry use declined as the summer progressed even though berry abundance increased. This suggested that mushrooms were preferred over berries, a finding also suggested by Martell (1981). Insect use also declined as the summer progressed. Since observations of insect abundance were not made, it is difficult to determine whether insects were less preferred or less available later in summer. Other items in the Northern Red-backed Vole diet did not change appreciably through time, except for lichens which were used more frequently as summer progressed. The pattern of seasonal use of food items by Northern Red-backed Voles in Alaska was very similar to the pattern Martell (1981) observed for Southern Red-backed Voles (*Clethrionomys gapperi*) in Canada.

Food eaten by Red-backed Voles in disturbed and undisturbed sites were similar but their frequency of occurence in the diet was different, (χ = 491.5 $P < 0.0005$) (Table 2). Fungi epigeous, and hypogeous combined, were a major food in disturbed and undisturbed sites. Red-backed Voles living in disturbed sites utilized more *Endogone*, while voles living in undisturbed sites used more mushrooms. Berries comprised a larger percentage of the diet of voles living in undisturbed sites than those living in disturbed sites. However, berries did not appear to be eaten as frequently as

TABLE 1. Summer food habits of voles on the Kenai Peninsula lowlands in 1977 presented as the percentage a food item occurred in the total number of identifiable food items. Numbers of animals examined are given in parentheses below the dates.

Species	Northern Red-backed Voles					Meadow Voles
Food Items	July 20–23 (36)	August 3–6 (23)	August 24–27 (22)	September 13–16 (32)	All Dates (113)	(19)
Berry	22	15	8	8	13	0
Mushroom	3	18	33	34	23	0
Endogone	25	27	32	25	27	20
Moss	10	3	5	1	5	15
Lichen	7	8	11	23	14	1
Insect	16	18	4	3	9	1
Grass	7	3	1	1	3	42
Other	9	6	4	4	5	21

TABLE 2. Summer food habits of Northern Red-backed Voles in disturbed and undisturbed sites on the Kenai Peninsula lowland in 1977 presented as the percentage a food item occurred in the total number of identifiable food items. Numbers of animals examined are given in parentheses.

Food Item	Disturbed Sites (45)	Undisturbed Sites (68)
Berry	7	18
Mushroom	11	32
Endogone	47	11
Moss	3	6
Lichen	18	12
Insect	6	11
Grass	3	3
Other	5	6

West (1982) reported for Northern Red-backed Voles in interior Alaska. Table 1 or 2 do not include data from snap trapping in May of 1978. Stomachs from these Red-backed Voles were visually examined for the presence of lowbush cranberry. Berries from the previous fall were commonly used by these voles. Of 104 Red-backed Voles examined, at least 47% had a noticeable amount of purple material in the stomach, indicating cranberry use. Red-backed Voles captured in undisturbed sites ate cranberries more often (55%) than voles caught in disturbed sites (37%).

The preferred food of Meadow Voles was grass (Table 1). All Meadow Voles caught and examined in this study were caught in recently disturbed areas in thick grass, the typical habitat of Meadow Voles (Zimmerman 1965; Richens 1974). Meadow Voles did not eat berries or mushrooms probably because both occur infrequently in grass stands. Zimmerman (1965) also reported little mushroom use by Meadow Voles. Although it was possible that mushrooms were not a preferred food item, it is unlikely since Meadow Voles frequently ate the fungus *Endogone* (Table 1).

The only food used frequently by both Red-backed and Meadow voles were moss and *Endogone*. Although moss comprised only a small portion of the Red-backed Vole's diet, it was commonly used by Meadow Voles (Table 1). Chitty (1967) also reported that Meadow Voles ate moss, but that the diet was primarily grass, as indicated by this study. West (1982) reported that moss was an important part of Red-backed Vole summer food habits in Interior Alaska. Prinz (1981) suggested that herbivores may utilize moss in northern environments to obtain polyunsaturated fatty acids. *Endogone* is reportedly an important winter food for small mammals (Bakerspigel 1958) and was the only major food item used by both Red-backed and Meadow voles during this study. Possible competition for this food may help explain the reported intolerance of these two species to one another (Turner et al. 1975).

The feeding strategies of Northern Red-backed Voles and Meadow Voles on the Kenai Peninsula were similar to those of Southern Red-backed Voles in Canada (Martell 1981), Northern Red-backed Voles in Interior Alaska (West 1982) and Meadow Voles in Interior Alaska (Whitney 1976). Meadow Voles were more specialized, fed primarily on grasses and *Endogone*, and were found only in localized thick grass stands. Red-backed Voles were generalist feeders utilizing whatever fungi, fruit, or lichen was available at that location, during that particular time of the summer, although preference for fungi, particularly *Endogone fascilulata,* was shown. This probably explains why Northern Red-backed Voles have so successfully adapted to spruce forest successional stages in Alaska (West 1982; Bangs 1979). Since neither species of voles appeared to feed on tree seeds or seedlings during the summer, it is doubtful that they had any detrimental affect on the reforestation of recently disturbed sites. Since small mammals are the primary means by which hypogeous fungi spores are dispersed (Maser et al. 1978) the extensive use of hypogeous fungi by voles promotes the symbiotic relationship between mycorrhizal fungi and higher plants in disturbed forest areas on the Kenai Peninsula, Alaska.

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Computer-Readable Data Sheets[1]

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Lautenschlager, R. A. 1984. Computer-readable data sheets. Canadian Field-Naturalist 98(4): 492–494.

Computer-readable data sheets developed from "General Purpose-10 choice answer sheets" are recommended for studies attempting to gather large amounts of repetitious data. These data sheets are particularly suited for feeding, behavioral, vegetation and laboratory studies. They save time and money, increase accuracy and eliminate potential transformation errors.

Key Words: computer-readable, data, recording, Moose, White-tailed Deer, food habits

In an attempt to transfer data quickly, accurately and cheaply from the field or laboratory into a computer readable format, engineers have recently developed portable electronic data recording systems. Although these systems are ideal for some studies they have several limitations: cost, bulkiness, potential cold weather battery problems and the need of a nearby computer facility for data transferal.

While designing a project to determine the food habits of tame Moose (*Alces alces*) and White-tailed Deer (*Odocoileus virginianus*) I considered using an electronic data recording system but rejected it because of several of the limitations mentioned above. In the past this kind of field data has been dictated into a portable tape recorder and later transferred to data sheets. However, I anticipated recording an extensive amount of data and hoped to eliminate any intermediate steps in data transfer. In addition, for safety reasons it was essential to have an assistant. Therefore I sought a recording system that could be used quickly and easily by an assistant and could be easily learned by new assistants.

Entering the data directly onto IBM "FORTRAN Coding Forms" was considered but rejected because even though I only hoped to record every other "bite" taken by these animals, it would have been impossible to keep pace with a feeding animal using these forms. In addition, the anticipated amount of data would have required a large investment (time and money) for keypunching prior to analysis. "Mark-Sensing," which allows automatic card punching by entering pencil marks on computer cards, has been used to gather forestry data (Husch et al. 1972). Although it was closer to what was desired, the need to mark all holes and the anticipated large number of loose cards made it impractical. The system described by Loveless et al. (1966) seemed to approach my needs. It employs a template overlay (which aids in locating the correct

[1]Mention of specific trade or company names does not imply product recommendation to the exclusion of others which may be suitable, nor endorsement of those products by the University of Maine.

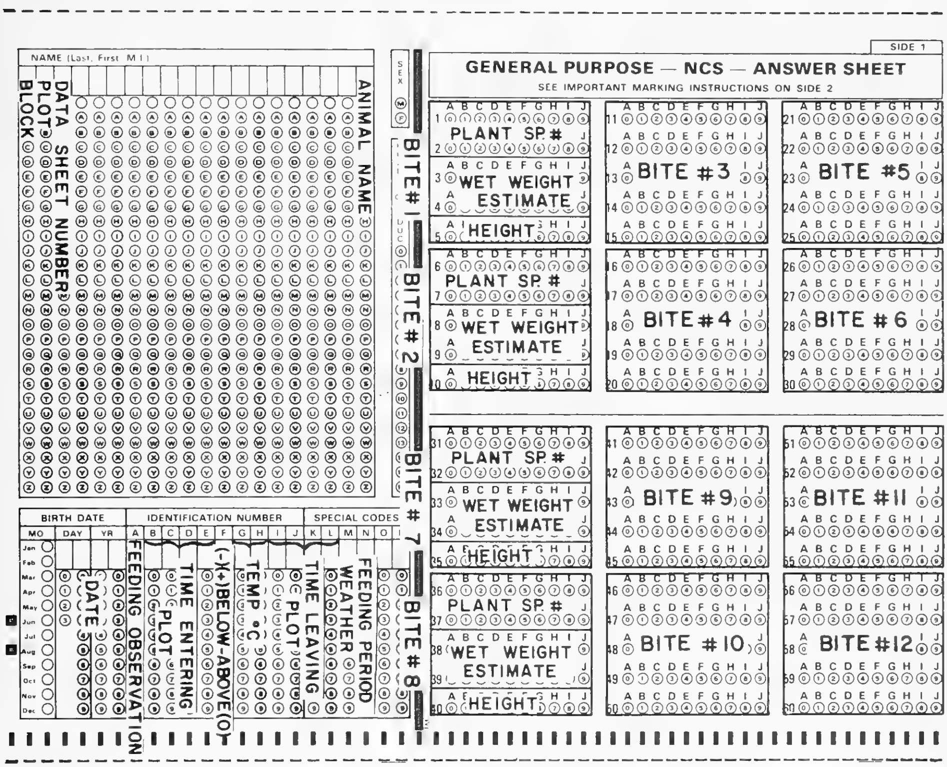

FIGURE 1. Computer-readable field data sheet.

mark position) placed on an 800-position Optical Mark Page reader. However, since this system was described standardized computer-readable test forms (which eliminate the need for a template overlay) have become commonplace.

I designed a computer-readable data sheet (CRDS) using a "General Purpose-10 choice answer sheet" (supplied by National Computer Systems, Forms Division, 2125 4th St. N.W., Owatonna, Minnesota 55060). Facilities to read CRDS are available at most academic institutions where standardized answer sheets are used. The CRDS format, including header information and data entry placement (Figure 1) allowed entering 24 animal "bites"/sheet (12 animal "bites"/side). Once a plant species and height code was entered they were left blank until they changed. Using this system, as long as the sheets were in order, it was only necessary to record the wet weight estimate of every other "bite" until the plant species eaten and/or height category changed. That change was then recorded along with the estimated "bite" weight.

Two people were used to gather data using this system, an animal handler, who observed the "bites," and a recorder. Recorders were trained to use CRDS in about eight hours. They learned best by first transcribing from previously tape-recorded feeding observations and then by recording in the field with the assistance of an experienced recorder.

Data were collected on CRDS for 14 months. At the completion of the study the CRDS were read on an optical mark reader. Table 1 compares the number of sheets needed, necessary processing time and the cost of using CRDS to using IBM "Fortran Coding Forms" as data sheets. After the CRDS were read, a FORTRAN program filled in the blanks with the previous information whenever the plant species and height codes had not changed. At the end of the study two deer which had been observed for 10 months had eaten approximately 41 000 "bites," half of which were recorded on 860 CRDS, and three moose which had been observed for 14 months had eaten approximately 144 000 "bites," half of which were recorded on 3000 CRDS.

The most important constraint on field use of

TABLE 1. A comparison of IBM "FORTRAN Coding Forms" to computer-readable data sheets (CRDS)[a]

Data Sheet Type	No. Sheets Required	Cost of Sheets	Processing Time	Processing Cost	Total Cost
IBM "FORTRAN Coding Forms"	660	$10	50 hr	$360	$370
CRDS	4000	$200	3 hr	$40	$240

[a]Estimates from the University of Maine Computer Center June 1982

CRDS was keeping them relatively dry, clean and unwrinkled. Therefore on rainy days a hand-held tape recorder was used and data were later transcribed to the CRDS. However, during the coldest weather, when the tape recorder batteries functioned poorly and writing legible numbers was impossible, CRDS were essential.

CRDS are not recommended for all studies. They are not practical or appropriate for small data sets and are not necessary if one can afford or use an electronic digital field recorder. However, they seem particularly suited for feeding, behavioral, vegetation, and laboratory studies. During this study CRDS saved time and money, increased accuracy and eliminated potential transformation errors. Although an observer and recorder were employed during this study CRDS are easily used by a single observer. Therefore CRDS should be considered for any study attempting to gather a large amount of repetitious data.

Acknowledgments

I thank Dianne Degnen, Sally Ahlefeld, Julie West, Peter Wayne and Lisa Pucci, who spent many (sometimes cold or hot and bugfilled) hours recording on these CRDS. Also, I thank Jerry Longcore, Richard Hosmer, Hewlette S. Crawford and C. Tattersall Smith for their comments on an early draft of this manuscript.

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Range Extension of the Orangespotted Sunfish, *Lepomis humilis*, to the Canard River, Essex County, Ontario

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Noltie, Douglas B., and Frank Beletz. 1984. Range extension of the Orangespotted Sunfish, *Lepomis humilis*, to the Canard River, Essex County, Ontario. Canadian Field-Naturalist 98(4): 494–496.

A total of eight Orangespotted Sunfish, *Lepomis humilis*, were captured on 21 and 23 June 1983, in the Canard River, Colchester North Township, Essex County, Ontario. This represents only the second report of this species in Canada, and extends the species' range in southwestern Ontario northward and inland 10 km from Cedar Creek, formerly the northernmost record.

Key Words: Orangespotted Sunfish *Lepomis humilis*, range extension, Ontario, length, weight, age.

On 21 and 23 June 1983, we collected a total of eight Orangespotted Sunfish, *Lepomis humilis*, in the Canard River (42°07′24″N, 82°50′51″W), Colchester North Township, Essex County, of southwestern Ontario. The Canard River drains into the Detroit River 20 km south of Windsor, Ontario.

The fish were captured using a 7.6 × 1.2 m nylon bag seine with 0.8 cm stretched mesh. The river at the capture site was shallow (maximum depth 0.6 to 1.4 m), slow flowing and silt-laden, with visibility to only a few centimeters, and free from aquatic macrophytes and tree roots, all features common to the species' habitat further south (Barney and Anson 1922; Carlander 1977). The bottom was primarily composed of clay and silt, with some patches of firmer sand. Other fish caught concurrently were White

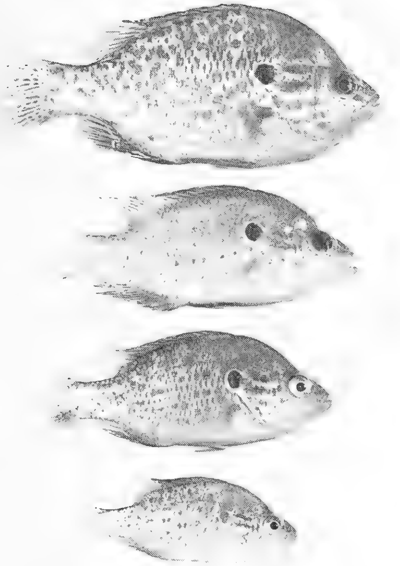

FIGURE 1. The four largest Orangespotted Sunfish captured in the Canard River, Ontario, in June, 1983. See Table 1, numbers 5 to 8, for lengths, etc.

Crappies (*Pomoxis annularis*), Gizzard Shad (*Dorosoma cepedianum*), Green Sunfish (*Lepomis cyanellus*), Carp (*Cyprinus carpio*), Emerald Shiners (*Notropis atherinoides*), and Yellow Bullheads (*Ictalurus natalis*).

The specimens were identified by the conspicuous spotting pattern on their sides, their flexible opercular flaps, and lengthened preopercular sensory openings (Trautman 1981). Four of the specimens were photographed (Figure 1), but voucher specimens were not saved.

All of the fish were measured (total length), weighed using a Mettler PC4400 DeltaRange top-loading balance, sexed when possible by gamete extrusion and body colouration, and aged by the scale method (Bagenal and Tesch 1978) (Table 1). Fish which could be sexed were greater than the 48 mm minimum size at maturity quoted by Lee et al. (1980). The presence of several age classes, and numbers of sexually mature adults, are indicative of a possible reproducing population. The weight-length regression equation was: $\log_{10}W = -12.31 + 3.31 \log_{10}TL$. Both the slope and correlation coefficient significantly differed from zero ($p < 0.001$, t-test, two-tailed). These results are similar to those reported by Carlander (1977).

Trautman (1981) stated that the first Orangespotted Sunfish recorded in the Lake Erie drainage basin were sampled in 1929 in Lake St. Marys, Ohio, from which rapid range expansion northeastwards through that state occurred. Before its discovery in Cedar Creek, Ontario (Holm and Coker 1981), its most northerly reported progress had been to Lake Erie's South Bass Island area in 1952 (Trautman 1981).

If the present population is derived from that reported by Holm and Coker (1981), three possible routes to the Canard River site exist: (1) Cedar Creek to Lake Erie, up the Detroit River, and into the Canard River, a total distance of about 80 km, (2) a tortuous 14 km direct water connection between the two sites via a municipal drain running parallel to Essex County Road #23, and (3) headwater capture of the Cedar Creek by the McClean Drain, a Canard River tributary, may have occurred, linking the two sites by 31 km of waterway. The weed-choked natures of the drains and the Cedar Creek and Canard River headwaters make the latter routes unlikely during dry periods. However, elevated water levels would assist movement, and the two populations so far discovered could conceivably been established coincidentally. Alternatively, a second invasion into Ontario from

TABLE 1. Total length, weight, age, and sex of eight Orangespotted Sunfish captured in the Canard River, Ontario, in June, 1983.

Fish number	Length (mm)	Weight (g)	Age Class	Sex
1	45	1.31	2	?
2	48	1.54	2	?
3	48	1.79	2	?
4	55	2.57	2	M
5	64	4.27	2	M
6	85	10.26	3	?
7	88	13.78	3	M
8	107	22.39	4	M
$\overline{X} \pm 1$ S.E.	67.5 ± 0.82	7.24 ± 2.70	2.5 ± 0.27	—

Ohio across Lake Erie and up the Detroit River could have occurred.

Holm and Coker (1981) stated that "specimens of *L. humilis* should be looked for in future surveys in the drainages of Lake Erie and Lake St. Clair because the range of this silt-tolerant species will likely continue to expand." Apparently, with man's continuing agricultural impact on southwestern Ontario waters in the form of heightened silt loadings, this prediction is becoming a reality.

Acknowledgments

We thank Drs. Miles H. A. Keenleyside, E. J. Crossman and Don E. McAllister, and Hélène M. C. Dupuis, for their helpful criticism of drafts of this manuscript, and Ian Craig for photography. Monetary support for this work came from NSERC operating grant number SO35A2 awarded to MHAK.

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Warmouth, *Lepomis gulosus*, a Freshwater Fish New to Canada

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Crossman, E. J., and Robert C. Simpson. 1984. Warmouth, *Lepomis gulosus*, a freshwater fish new to Canada. Canadian Field-Naturalist 98(4): 496–498.

The occurrence in Canada of the centrarchid *Lepomis gulosus* (Cuvier), Warmouth, is documented on the basis of specimens from the waters of Lake Erie in and near Rondeau Provincial Park and Point Pelee National Park.

Key Words: Warmouth, *Lepomis gulosus*, first Canadian record, Lake Erie

The latest northward movement of freshwater fishes into Canada, which began about 14 000 years ago as the Wisconsin glacier began to reduce, continues. Since 1968, at least six warm-adapted species which might be considered recent, natural migrants, have been reported from southern Ontario. Pioneer populations often go undetected, or are mistaken for known species, for several years prior to documentation.

The latest species to be documented is the centrarchid *Lepomis gulosus* (Cuvier), the Warmouth. The earliest known specimen was captured from Lake Erie at Rondeau Provincial Park (42°17′N, 82°31′W) by Roger E. Roy on 5 June 1966 and is housed in the Rondeau Park Museum (RPM F103-66). Two further specimens were captured there in 1967, and three in 1968. No other specimens were reported until 31 March 1983 when one specimen (ROM 42752) was captured by G. Mouland farther west on Lake Erie in Lake Pond, Point Pelee National Park (41°58′N, 82°31′W).

Between 3 June and 18 October 1983, Mr. Mouland captured a total of 46 additional specimens from the same location. These consisted of 28 adults and 18 young-of-the-year. All but two of these were released alive. Two specimens, 155 and 90 mm TL, were

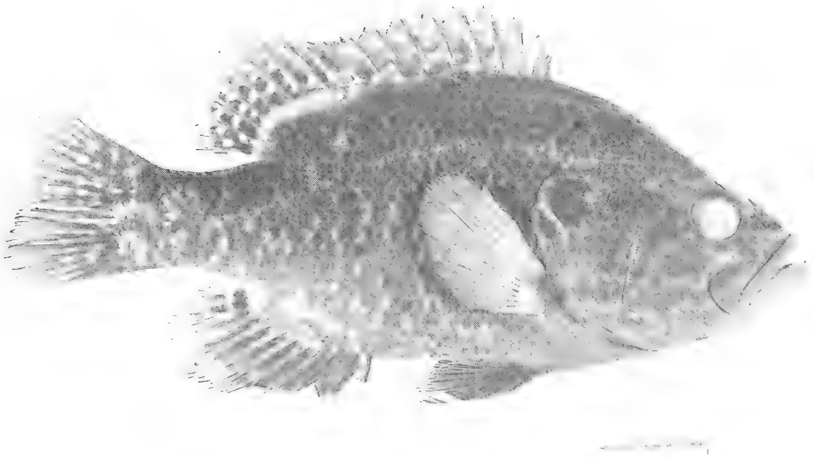

FIGURE 1. A specimen of *Lepomis gulosus* ROM 43022 captured by G. Mouland in Lake Pond, Point Pelee National Park, 3 June, 1983. The specimen is 155 mm TL. Note the large mouth, the three anal spines, and the round clear spots on the second dorsal fin.

retained as reference specimens (ROM 43022). No other records resulted from queries sent out, in late 1983, to all fisheries agencies along the Ontario shores of Lake Erie and of the Detroit and St. Clair rivers.

The only published notation of this species in Canada was a brief note (p. xv) in a section of new information added to the third printing (1979) of *Freshwater Fishes of Canada* (Scott and Crossman 1973).

The northern limit of distribution of the species (Lee et al. 1980) is a line from central Wisconsin to Maryland. The species extends southward to the Gulf coast, from Florida to Texas, and westward from the Atlantic coast to New Mexico. Although these Lake Erie records are the first from Canada, the species does occur farther north in Wisconsin (approximately 45° N, 89° W). The nearest populations are those in Michigan tributaries of Lake Erie rather than those across the lake in Ohio. Regardless of their source, it seems more likely that the pioneers moved around the shore rather than across the lake. In that case, one would have expected them to have appeared first at Point Pelee rather than Rondeau. It is also of interest that, although no further specimens have apparently been seen at the original Rondeau location, a breeding population has been established at Point Pelee.

The known captures of Warmouth have been from ecological situations typical of sunfishes. Other centrarchids — *L. gibbosus, L. macrochirus, Pomoxis annularis, P. nigromaculatus, Micropterus salmoides*, and other "warm-water" fishes — *Amia calva, Ictalurus nebulosus, Perca flavescens* — were captured with this species at Rondeau Provincial Park in 1968.

ROM specimens (34267 Rondeau; 42752 and 43022 Point Pelee) were checked for meristic and morphometric characters. All values fall within the published ranges for the species.

Warmouth in Canada are most likely to be confused superficially with *Ambloplites rupestris*, Rockbass, and *Lepomis cyanellus*, Green Sunfish, the other small species of large-mouthed sunfishes. Existing keys to Canadian centrarchids, constructed without reference to *L. gulosus*, will probably identify specimens of *L. gulosus* as *L. cyanellus*. *Lepomis gulosus* differs from *Ambloplites rupestris* in having only

three anal spines instead of six. *L. gulosus* differs from *L. cyanellus* by the presence of many teeth on the tongue, round clear spots on the second dorsal fin (hard to see in preserved animals), and dark bands radiating out from the eye. *L. cyanellus* usually has an obvious black spot at the base of the last rays of the second dorsal fin and sometimes a less conspicuous one at the base of the last anal rays. There are no such spots on *L. gulosus*, and instead there is a line of black pigment across the base of all dorsal rays. Breeding males of *L. gulosus* do, however, have a bright orange spot at the base of the last dorsal fin rays.

All agencies along the Canadian shore of Lake Erie and its tributaries have been asked to watch for this sunfish and to report it in an attempt to document the rate of establishment of a new species. There have been recent records (Holm and Coker 1981; Nolte and Beletz 1984) of another sunfish, *L. humilis*, the Orange-spotted Sunfish, new to the Canadian fauna. Those records (Cedar Creek — Lake Erie, Canard River — Detroit River) suggest that *L. gulosus* might appear north of Lake Erie as well.

Acknowledgments

We would like to thank the various people who recognized the possibility that they were dealing with a species new to Canada, and who assisted in making this information available to others: Roger Roy and Bruce Thacker apparently caught the 1966 specimen and tentatively identified it as *L. gulosus*. At different times, specimens were checked and the identification verified by S. J. Nepszy and D. E. McAllister. We also acknowledge the assistance of K. H. Loftus, G. Mouland, W. B. Scott, J. H. Tadgham, M. Walters, and the representatives of Lake Erie agencies who replied to our queries. Erling Holm took the photo for Figure 1.

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Dog, *Canis familiaris,* Killed by a Coyote, *Canis latrans,* on Montreal Island, Quebec

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Bider, J. Roger, and P. Gregory Weil. 1984. Dog, *Canis familiaris,* killed by a Coyote, *Canis latrans,* on Montreal Island, Quebec. Canadian Field-Naturalist 98(4): 498–499.

This is a documentation of the killing of a dog by a single Coyote. The dog had been with its owner who was cross-country skiing at dusk. After the kill, the coyote joined two others of its pack, and the dog was partly eaten.

Key Words: dog, coyote, predation, Montreal Island, Eastern Canada.

Wolves, *Canis lupus,* in packs have been known to kill dogs, *Canis familiaris,* in Europe (Zimen and Boitani 1979; Erkki Pulliainen 1979). They have also been known to attack and kill Coyotes, *Canis latrans* (Seton 1929; Young and Goldman 1944; Munro 1974; Stenlund 1955). Although vague assertions are made stating that Coyotes have been known to kill dogs, we were unable to find any documentation in literature. The following is an account of a dog killed by an Eastern Coyote in the Morgan Arboretum of McGill University, located at the western extremity of Montreal Island, Quebec (45° 24′N, 73° 57′W).

At 1800 hours on 1 March 1983, a cross-country skier was travelling diagonally across an open 300 m square field. The sun had set at 1740 hours. The sky was overcast and the light was fading. The skier's dog, an 11.36 kg male Cavalier King Charles Spaniel, was trailing him by 70 m. As the skier reached the edge of

the woodline, he heard a sharp yelp and turned to see his dog being carried off by a large canid. He chased the animal that was carrying his limp dog 200 m and was gaining on it when it turned into the woods and was no longer pursuable.

At 1900 hours, we arrived on the scene to determine what had killed the dog. There were 8 cm of crusted snow on the ground which had been softened during the mild afternoon. Reconstruction of the hunt from tracking indicated that two Coyotes had been hunting in an adjacent field; one entered the woods, the other followed the edge to the corner of the woods and observed the dog and skier crossing the adjacent field. The Coyote loped and ran straight to the ski trail, then turned sharply pursuing the dog 6 m. Presumably, it lifted the dog off its feet and killed it instantly. It then turned, running back from where it came. It ran along the edge of a second field then cut into the woods and slowed its pace to a brisk walk. It moved through a managed maple woodlot, into a larch stand, over an old stone wall and into an open field interspersed with young dead elms. The total distance travelled while carrying the dog was 400 m. There were occasional blood spots and almost a continuous body drag in the snow created by the dog.

At the feeding site, blood trails and prints indicated the following scenario: the dog was put on the snow and opened along the sternum in typical Coyote fashion. Part of the rib cage and muscles along the flank were eaten. The skin was not found. The organs were left nearly intact. At this point, the now bloody carcass was dragged 40 m in two large meandering loops. There it was abandoned with the small intestine cut and lying on the snow perpendicular to the carcass.

There were Coyote prints all over the area extending 5 m on each side of the blood trail, which clearly indicated that either other Coyotes had joined the hunter or the hunter had joined other Coyotes. A more detailed study of the tracks the following morning indicated that three Coyotes had travelled east another 200 m from the feeding site into the centre of an open field where more smudges of blood, presumably from the missing piece of skin being dragged about, were found. After travelling together another 150 m south to the edge of the field, the tracks diverged. Tracks indicated that at least one Coyote returned to both the kill and feeding site during the night.

A pack of Coyotes had been reported on the west part of the Island over the past year. Four Coyotes were often seen months earlier. A Coyote was found dead in the area on the TransCanada Highway in February 1982. Separate multiple kills of sheep and goat occurred over the summer within the territory. Three Coyotes had been travelling within 1 km of the kill site four days previous and were seen in the same area at 600 hours the day of the dog kill.

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Distributional Records of Bats from the James Bay Region

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Nagorsen, David W., and S. V. Nash. 1984. Distributional records of bats from the James Bay region. Canadian Field-Naturalist 98(4): 500–502.

Locality records from southern James Bay are reviewed for five species of bats: the Little Brown Myotis (*Myotis lucifugus*), Eastern Long-eared Bat (*Myotis septentrionalis*), Red Bat (*Lasiurus borealis*), Hoary Bat (*Lasiurus cinereus*), and Silver-haired Bat (*Lasionycteris noctivagans*). These records are at the northern limits of the geographic ranges of these five species in eastern Canada. However, it is unknown if these specimens represent stray migrants or individuals that are summer residents in the James Bay region.

Key Words: *Myotis lucifugus, Myotis septentrionalis, Lasiurus borealis, Lasiurus cinereus, Lasionycteris noctivagans,* James Bay, geographic distribution.

The geographic distribution of bats in northern Ontario and Quebec is poorly known because of the paucity of specimen records. Peterson (1966) reviewed known specimens and reported that only two species, the Little Brown Myotis (*Myotis lucifugus*) and Silver-haired Bat (*Lasionycteris noctivagans*), occur as far north as the James Bay region. However, during field research in the Hudson Bay Lowland of Ontario in 1979–81, specimens of three additional species, the Hoary Bat (*Lasiurus cinereus*), Red Bat (*Lasiurus borealis*), and Eastern Long-eared Bat (*Myotis septentrionalis*), were obtained from southern James Bay. Herein we review known museum specimens for these five species from the James Bay region and discuss the northern limits of their geographic ranges in eastern Canada.

Specimens Examined and Locality Data

Specimen data (localities, collecting dates, sex, catalogue numbers) were taken from specimen labels or collectors' field notes. Method of capture is given if known. We follow van Zyll de Jong (1979) in treating the Eastern Long-eared Bat as a distinct species (*Myotis septentrionalis*). Common and scientific names for other species are from Jones et al. (1982). Abbreviations for institutions are: (CM), Carnegie Museum of Natural History, Pittsburgh; (NMC), National Museum of Natural Sciences, Ottawa; (ROM), Royal Ontario Museum, Toronto; (USNM), National Museum of Natural History, Washington, D.C. Localities are shown in Figure 1.

Little Brown Myotis (*Myotis lucifugus*)
Ontario: Fraserdale, 1 ♂, 30 June 1939 (ROM 13625). Moose Factory, 1, sex unknown, 1929 (ROM 33.6.20.951). Quebec: Rupert-House (Fort Rupert), 1, sex unknown, no collecting date (USNM 11160).

Although Hall (1981:192) showed this species to occur throughout the Hudson Bay Lowland to the coast of Hudson Bay, there are no specimens to substantiate such a distribution.

Eastern Long-eared Bat (*Myotis septentrionalis*)
Ontario: Moosonee, 1 ♀, 12 August 1981 (ROM 86721).

This bat was found roosting on the outside wall of a building.

The Moosonee record is about 400 km north of known records for this species in Ontario and Quebec.

Silver-haired Bat (*Lasionycteris noctivagans*)
Ontario: Moose Factory, 1 ♀, 23 September 1912 (CM 2591); 1 ♀, no collecting date (USNM 5295). Onakawana, 1 ♂, 1 ♀, 3 August 1939 (ROM 13622, 13623). Moose River Crossing, 1 ♂, 11 August 1939 (ROM 13624).

Nearest records are from southern Quebec and the north shore of Lake Superior in Ontario (Peterson 1966).

Red Bat (*Lasiurus borealis*)
Ontario: North Point, 1, sex unknown, 8 August 1979 (NMC 45474); 1 ♀, 22 August 1981 (NMC 45607).

Both bats were taken in mist nets set for migrating shorebirds on the tidal flats of James Bay.

These specimens represent the first records for this bat from the Hudson Bay Lowland. A specimen from Southampton Island in northern Hudson Bay is so far north of the geographic range that it probably represents a stray migrant (Banfield 1961 and 1974).

Hoary Bat (*Lasiurus cinereus*)
Ontario: North Point, 2, sex unknown, 19 August 1979 (NMC 45472, 45473); 1 ♂, 10 August 1981 (NMC 45606).

All were taken in mist nets set for migrating shorebirds on the tidal flats of James Bay.

These records are about 500 km north of nearest

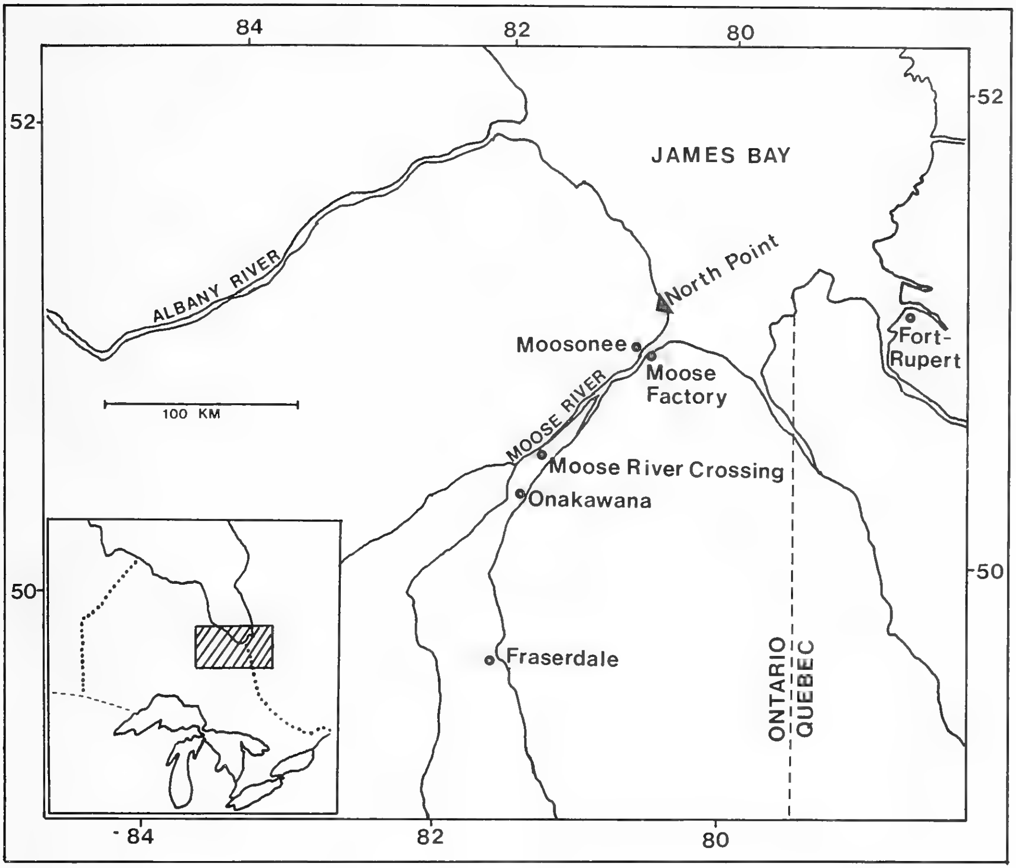

FIGURE 1. Map of the southern James Bay region showing geographic features and known collecting sites for bats.

locality records in Ontario and Quebec (Peterson 1966). Although the map in Hall (1981:226) shows this species extending along the coast of Hudson Bay as far north as Southampton Island in the Northwest Territories, there are no records from the coast of Hudson Bay in Quebec, Ontario, or Manitoba (Peterson 1966; Banfield 1974). Hall (1981) presumably based his distribution on the single specimen record from Bear Island in northern Hudson Bay. This locality is considerably north of the known range and probably represents an accidental occurrence (Hitchcock 1943; Banfield 1974).

Discussion

Additional research is required to determine if the bats reported herein represent stray migrants or permanent summer residents in the James Bay region. Red, Hoary, and Silver-haired bats do not overwinter in Ontario or Quebec and they migrate south to the United States (Peterson 1966). Because all specimens of these species were taken in August and September when they begin autumn migrations (Peterson 1966; Barbour and Davis 1969), the James Bay records could represent migrants that strayed north of their summer range. Red, Hoary, and Silver-haired bats have not been collected from this region in June or July when females would be expected to be nursing young and, therefore, it is unknown if their maternity ranges extend as far north as James Bay.

Similarly, the few collecting dates for the Little Brown Myotis and Eastern Long-eared Bat make it impossible to verify that these species reside in the

James Bay region during the maternity period. Moreover, as yet, no nursery colonies are known from this area. Both species overwinter in caves and abandoned mines in Ontario and Quebec (Fenton 1970; Nagorsen 1980). There are no caves or mines in the vicinity of James Bay and the Little Brown Myotis and Eastern Long-eared Bat would have to migrate south from James Bay to hibernacula on the Canadian Shield. Nearest known hibernaculum is the Gowganda Mine (Wigwam Mine) about 400 km south of Moosonee in northeastern Ontario (Nagorsen 1980).

All of the records from James Bay are at the northern limits of the geographic range for the Little Brown Myotis, the Eastern Long-eared, Silver-haired, Red, and Hoary bats but additional study is required to delimit their precise geographic ranges in northern Quebec and Ontario. The concentration of specimen records from southern James Bay can be attributed to collecting bias. The fauna of southern James Bay has been better surveyed than other remote regions in Quebec and Ontario. Field studies in these regions may reveal that bats range as far north as the northern Canadian Shield or southern Hudson Bay Lowland. It is unlikely, however, that bats normally inhabit the treeless tundra on the Ungava Peninsula and the coast of Hudson Bay in eastern Canada.

Acknowledgments

Bats were collected at North Point in 1979 by Steve Nash while employed by the Canadian Wildlife Service (CWS). Specimens from North Point in 1981 were collected by Barbara Campbell (CWS). We thank Dr. R. I. G. Morrisson (CWS) for allowing us to publish on these specimens. David Campbell (NMC), Dr. Hugh Genoways (CM), and Robert Fisher (USNM) provided data from specimens. ROM field research in the Hudson Bay Lowland was financed by research grants from the Canadian National Sportsmen's Fund to Dr. Randolph Peterson. Drs. James Tamsitt and Randolph Peterson critically read the manuscript.

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Training White-tailed Deer, *Odocoileus virginianus*, for Food Habit Studies

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Lautenschlager, R. A., and H. S. Crawford. 1984. Training White-tailed Deer, *Odocoileus virginianus*, for food habit studies. Canadian Field-Naturalist 98(4): 503-505.

We raised seven and trained 10 White-tailed Deer (*Odocoileus virginianus*) for a food habits study. All were one to seven days old when acquired and were trained to load into a transport vehicle and follow handlers. Trainers spent several h/day feeding, stroking, and talking to the deer before training began. For training we recommend (1) a small holding pen so the deer remains close to the trainer, (2) continual contact between handlers and the deer, which was more important than imprinting, (3) making the transport vehicle an area of security, (4) using at least two handlers, (5) working with deer individually, (6) training doe fawns if the deer must be restrained and led, (7) using a stout leather dog collar instead of a harness.

Key Words: training, White-tailed Deer, *Odocoileus virginianus*, food habits.

The use of "tamed" wild ungulates for studying food habits has increased since its inception about three decades ago (Wallmo and Neff 1970). Although both Mule Deer (*Odocoileus hemionus*) and White-tailed Deer (*Odocoileus virginianus*) have been trained for this purpose, a distinction must be made between techniques which are successful with Mule Deer versus those for the less social more "nervous" (Geist 1980) and less-tractable White-tailed Deer.

Tamed White-tailed Deer have been used in a number of field studies (McMahan 1964; Watts 1964; Healy 1971; Whelan et al. 1971; Crawford et al. 1975; Stormer and Bauer 1980); however, training techniques, when reported, have varied. We developed new techniques for training White-tailed Deer which differed from those previously reported.

Training Methods

We trained four bucks (one castrate) and three does which we raised from fawns, and one buck and two does raised by others. All were bottle-fed after being removed from the wild at one to seven days of age. Feeding schedules, formulas, and housing were similar to those outlined by Buckland et al. (1975). Initially deer were fitted with adjustable harnesses similar to those described by Reichert (1972). However, these were rejected because when the harness was tight it seemed uncomfortable and restrictive and when it was loose it could slip over the deer's shoulders. Deer were then equipped with a 3-cm-wide leather dog collar covered with a brightly colored imitation-wool band. The wool band eliminated potential discomfort caused by the leather rubbing the deer's neck. The collar passed through a 3-cm (inside diameter) steel ring to which the lead rope was fastened. The lead rope was 3 m long, 2 cm in diameter and had a stout spring clip that could be attached to the collar ring.

Deer were kept in a pen that was approximately 5 m^2, and transported in a small truck modified by installing a 120 × 190× 200-cm plywood box on the bed. The bed of the truck was covered with wood chips or loose hay. A ramp door, hinged above the bumper at the back of the truck, allowed a walkway into the truck and covered the back of the box when closed. A 110× 170 cm swinging gate at the rear of the box kept the deer confined inside while the ramp door was being raised or lowered.

When loading, the truck was backed close to the holding pen and the ramp door lowered to the pen gate. Snow fence formed a walkway from the pen to the truck.

Training required that the deer continually associate with handlers (Reichert 1972; Buckland et al. 1975). Although we attempted to imprint individual fawns on specific handlers as suggested by Reichert (1972), consistent and gentle treatment was more important in producing "tame" deer than imprinting.

We began training fawns when they were about three weeks old. Although the fawns remained close to or followed the handler for the first six to nine months, it was important to initiate the pattern of manual restraint early so that, as these animals became independent (yearlings), they would be accustomed to restraint.

A buck and doe, acquired at six and nine months of age, respectively, followed the handlers after becoming familiar with them. However a doe acquired at 11 months always appeared "nervous". Newly acquired deer were fitted with a collar and ring, which sometimes required force. Later, we sat near these deer until they became accustomed to us. The small hold-

ing pen aided this acclimation because the deer remained close to the trainers. We attached a lead rope to each collar after this short adjustment period. The final step, after deer became accustomed to the rope, was to apply restraint.

Tolerance of a deer to restraint varied with the individual and its stage of training. Males tolerated little or no restraint, whereas females were more tolerant. Training time varied with individual deer, but normally each individual required about 2 h/day (10-12 h/week) for two to four weeks. After deer were trained they retained tractability with about 3 h/week of additional training.

Foods such as commercial ration, preferred browse species, and apple pieces were used as positive reinforcement when appropriate. Occasionally restricting their feed aided the training process as even a timid deer usually would approach us after only one day without food.

Vegetation was scarce inside the holding pen so deer were trained outside the enclosure. Deer were "led" with a rope outside where most began eating and tended to "ignore" the handler. The initial training sessions with the deer raised by others often were traumatic, but a necessary step in getting them to accept restraint. They improved gradually with additional training.

Feeding the deer commercial ration and various "treats" in the truck resulted in the deer accepting the vehicle as an area of security. Deer were taken into the field only after they adapted to being led and eating in the back of the truck; however, they received no supplemental food in the field.

Upon arriving near a plot we attached the lead rope while the deer was in the truck. This was easier and less traumatic than attempting to catch it in the larger holding pen. Deer were led to and from the plots, but while on the plots even though they were attached to a lead rope they were restrained and redirected only if they attempted to leave. This enabled us to maintain control and to be close enough to observe all plants eaten.

Deer were led back to the truck and into the box after foraging. The first attempts at moving newly trained deer sometimes required force; however, they quickly learned that going directly into the box was easiest.

Two people were needed for all training and handling phases. Deer were moved to and from plots most easily when one handler led (sometimes applying pressure via the lead rope) and another followed and prodded occasionally. Contact was not usually necessary from the rear handler; his presence at the rear was enough to cause a deer to keep moving. These techniques, modified to accomodate individual animals, enabled us to lead deer to plots more than 300 m from the truck.

Although two deer occasionally were transported and observed together, one animal in the field worked best because attention could be focused on that animal and that animal could only interact with the handlers.

Results and Discussion

All deer younger than six months of age showed a willingness to follow the handlers without restraint. However, half of the 10 deer we attempted to train, the males including one castrate, remained intractable, even though all were friendly when not restrained. Although the five females reacted differently to handlers and restraint all were used successfully. Figure 1 outlines the progression from fawn to tractable adult.

For training and field work with White-tailed Deer we recommend: (1) that researchers concentrate on training doe fawns if the animals must be restrained and led (Healy, Wallmo and Whalen agree (personal communication)); (2) use a stout collar instead of a harness; (3) employ a minimum of 2 handlers; (4) make the transport vehicle an area of security; (5) work with deer individually; and (6) provide continual contact between handlers and deer.

Acknowledgments

We thank A. W. Franzmann, W. M. Healy, W. W. Mautz, L. J. Verme and O. C. Wallmo for their reviews of this manuscript and Dianne Degnen and Sally Ahlefeld for training most of the deer.

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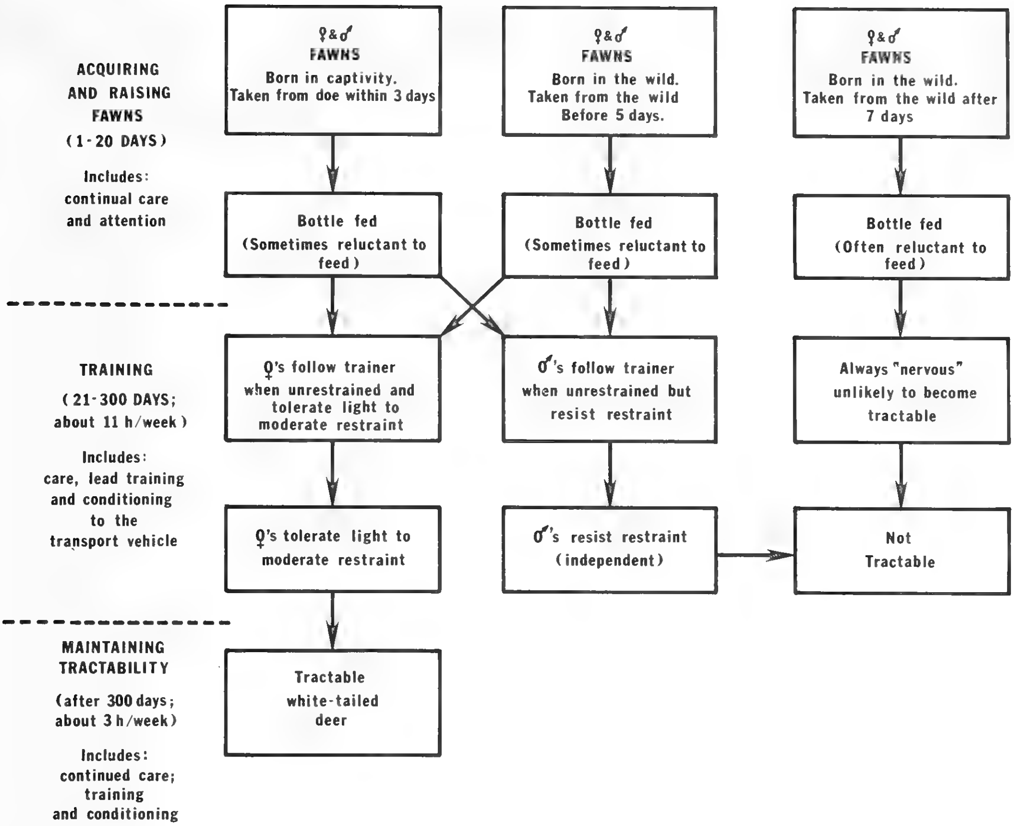

FIGURE 1. Flow diagram for developing tractable White-tailed Deer.

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Malocclusion of Incisor Teeth in a Red Squirrel, *Tamiasciurus hudsonicus*[1]

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[1]Provincial Museum of Natural History Contribution 74

Smith, Hugh C. 1984. Malocclusion of incisor teeth in a Red Squirrel, *Tamiasciurus hudsonicus*. Canadian Field-Naturalist 98(4): 506–507.

Malocclusion of incisor teeth in a Red Squirrel, *Tamiasciurus hudsonicus*, is described.

Key Words: malocclusion, incisor teeth, Red Squirrel, *Tamiasciurus hudsonicus*.

Incisors of rodents and lagomorphs continue to grow throughout the life of the individual. Rarely the upper and lower ones do not meet, normal abrasion or wear cannot take place, and the teeth continue to increase in length. Malformation of the incisor teeth of Woodchucks (*Marmota monax*) has been illustrated by Lincoln (1938), Schoonmaker (1966), Seton (1953), Thorpe (1930), Wagner (1923), Woods (1980). Shadle (1936) refers to cases of malocclusion in rabbits.

The first incidence known to me of this condition in the Red Squirrel (*Tamiasciurus hudsonicus*) is exhibited by a specimen in the Provincial Museum of Alberta (Z79.33.1). The animal, an adult male collected in Edmonton 21 February 1979, appeared to be in good health although the lower incisor was beginning to impinge on one eye (Figure 1), had punctured the skin of the jaw, and had continued to grow unhindered until it reached the eye (Figure 2).

The alveolus (tooth socket) for the left incisor has been displaced to the left approximately 4 mm. This is in contrast to normal individuals, where the alveoli, for the lower incisors are close together, almost touch at the mandibular symphysis. There is a small lesion on the outside of the left mandible just below P_4. As well, P_4 is missing, there is some erosion of the bone around M_1, and M_2 has signs of tooth decay (Figure 3).

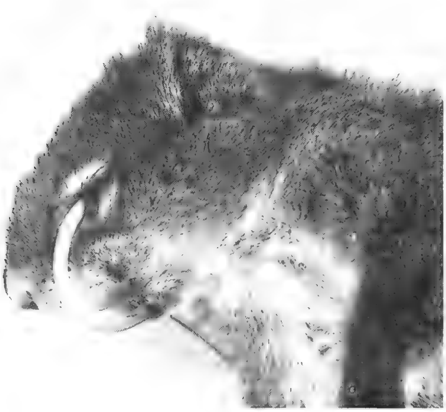

FIGURE 1. Incisor intruding into left eye.

FIGURE 2. Ventral view showing position of lower incisors and location of area the growing incisor penetrated in the skin.

The length of both the upper and lower incisors was estimated by laying a string along the outside curve of each tooth and measuring the length of the string with a ruler. In the aberrant specimen the length of the lower incisor is approximately 50 mm compared to a normal individual where it is approximately 16 mm. The upper incisor measured 25 mm in contrast to a normal specimen which measured 8 mm. Howard and Smith (1952) have shown that growth of the upper and lower incisors in rodents is rapid and that the increase in length is different. By using their data for the slowest increase (porcupine), the incisors in this aberrant Red Squirrel would take between 89 and 136 days to increase by 34 and 17 mm.

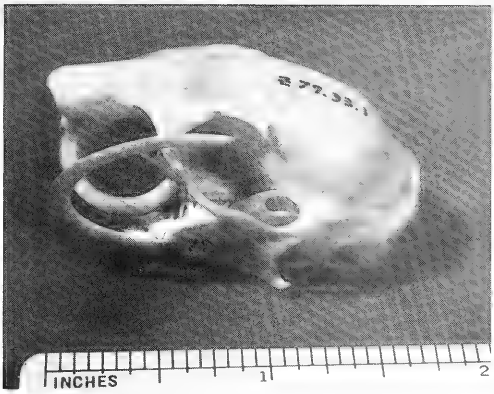

FIGURE 3. Cleaned skull showing lesion and extent of bone erosion on lower jaw and the amount of curvature in both upper and lower incisors.

The width of the lower left incisor has thinned uniformly from the base to the tip. The width of the base, measured at the alveolus, is 1.15 mm, at mid-point 0.97 mm, and at the tip 0.34 mm. The upper left incisor has uneven thinning. The base measured 1.20 mm at the alveolus. At a point approximately 1.6 mm from the tip of the upper right incisor, the left incisor width measured 0.34 mm, at mid-point it measured 0.74 mm, and at the tip 0.37 mm. The thin part could be the result of wear by the lower right incisor if the squirrel deliberately moved the lower jaw toward the left to compensate for the irritation to the left eye caused by the lower left incisor.

In the referred specimen the tips of the occluding incisors (the right side incisors) are blunted indicating that normal wear is not occurring (Figure 2), except for a small notch in the upper right incisor where the lower right incisor has made contact.

The left upper incisor appears to be almost a complete circle (Figure 3). The tip has met, but not penetrated, the maxillary bone. It is also touching P_4 and appears to have been deflected toward the left by this tooth. The pressure of the incisor on the maxillary bone has caused the root portion of the tooth to rupture the socket wall so that the posterior portion of the incisor has intruded into the nasal chamber. The turbinal bones in the nasal chamber are damaged, probably caused by the intruding tooth although this may have occurred during the cleaning process.

Had this individual continued to live it is probable that the lower incisor would have penetrated the left eye, as the tip of the tooth was already touching the eyeball. It is also likely that the upper incisor would have penetrated the maxillary bone. Even if either of these events did not cause death, the squirrel would have lived with certain discomfort.

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Aberrant Coloration in Two Least Chipmunks, *Eutamias minimus*, from Western Canada

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Smith, Hugh C. 1984. Aberrant coloration in two Least Chipmunks, *Eutamias minimus*, from western Canada. Canadian Field-Naturalist 98(4): 508.

Aberrant pelage coloration in two specimens of *Eutamias minimus* from British Columbia and Alberta is reported. One is melanistic and one is pale orange. Aberrant pelage coloration in the genus *Eutamias* is rare.

Key Words: *Eutamias minimus*, melanistic, aberrant pelage.

Aberrant pelage coloration in chipmunks occurs infrequently. Smith and Smith (1972) summarized the reported occurrences in Eastern Chipmunks (*Tamias striatus*). The only published report of aberrant coloration in western chipmunks, *Eutamias* spp., is that of Fleharty and Jones (1960) who reported a type of albinism in one Gray-collared Chipmunk, *Eutamias cinereicollis*, from New Mexico.

The Provincial Museum of Alberta has recently received two specimens of aberrantly pigmented Least Chipmunks, *Eutamias minimus*, from western Canada. The first specimen (number Z81.49.1), collected in northwestern British Columbia in 1976, was donated as a study skin. Unfortunately it had not been sexed or measured. It is smaller than other study skins of *Eutamias minimus* in the Provincial Museum of Alberta. Whether this is an artifact of the way the specimen was prepared or whether it is in fact smaller cannot be determined. Its pelage is totally black with no hint of the dorsal striping that is characteristic of this species. The specimen is uniformly black on both the dorsal and ventral surfaces, including the feet and tail. Smith and Smith (1972) described three melanistic *Tamias striatus* of which two showed faint striping and one was totally black.

The second specimen (number Z82.77.13), a female, was collected by W. Weimann on 21 August 1982 at Steen River, Alberta. Its color is diluted from normal and can be best described as pale orange. In a normally colored specimen the dorsal striping alternates between black and white. In the specimen reported here the alternate-striping pattern is evident but it is much paler. The stripes that are black in normal specimens are pale orange in this specimen. The white stripes are approximately normal in color. In normal specimens the body color is greyish-brown shading into russet on the shoulders but in this specimen the body color is much paler, without any shading on the shoulders. The top of the head, cheeks, and nose are greyish-white. The ventral surface is white. The tail is yellow-orange on both the dorsal and ventral surfaces, and is darker than the rest of the body. The feet are greyish. Standard body measurements are within the range of those of normal adult individuals (Soper 1964).

During the preparation of this note, I examined approximately 100 specimens of *Eutamias minimus*. As well, C. G. van Zyll de Jong, Curator of Mammals, National Museum of Natural Sciences, Ottawa, reported that his collection had no specimens of this species showing aberrant pelage coloration. I conclude that species of *Eutamias*, and particularly *Eutamias minimus*, seldom exhibit aberrant pelage color variation.

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[1]Natural History Contribution 72, Provincial Museum of Alberta, Edmonton.

News and Comment

New Honorary Members and 1983 Ottawa Field-Naturalists' Club Awards

At the 1984 Soirée four Honorary Memberships were presented along with four Club awards for Member of the Year, Service, Conservation, and the Anne Hanes Natural History Award. Certificates, indited in the fine hand of Anne Gruchy, were presented to winners by President Frank Pope, and citations are reproduced below.

Honorary Membership

Dr. Irwin M. Brodo

The Ottawa Field-Naturalists' Club is pleased to confer Honorary Membership on Dr. Irwin Brodo, lichenologist, and Chief, Botany Division, National Museum of Natural Sciences.

Dr. Brodo served for five years (1966–71) as Chairman of the Macoun Club, and subsequently continued to act as advisor to the senior group. He sparked an extremely active period in Macoun Club history, including acquisition of the use of a special nature study area at Bell's Corners, and introduction of an annual symposium in the senior group. He also organized the first wilderness summer camping trip with the Macoun Club, and devoted summer holidays (and those of his family!) to a wilderness canoe trip with Club members. During his chairmanship, the growth in membership of the Macoun Club and in members' contributions to the Club publication reflected his ability to fire young naturalists with enthusiasm.

Dr. Brodo was a member of Council for ten years (1966–76) and served on various committees, including Finance, Publications and Education. As president in 1973–74, he provided effective leadership and direction in an early stage of the Club's involvement in conservation issues. In his 1974 address to the Annual Meeting he noted that more briefs and submissions on conservation issues had been produced by the Club than ever before.

He has served naturalists and the community well in supporting efforts to retain significant natural areas — locally, provincially, and nationally. He has been active in the National and Provincial Parks Association of Canada, and was deeply involved in the struggle to save Gatineau Park from over-development, presenting briefs, writing letters and speaking on radio, television, and in public fora. He was able to bring good scientific knowledge and quiet good judgement to bear in influencing public and political attitudes toward nature conservation. Ottawans, and Canadians, owe him their gratitude for acting so effectively on their behalf.

Dr. Brodo is Canada's foremost lichenologist, and has been generous in sharing his professional knowledge with the Club, through field trips, workshops, and lectures, as well as writing a series of lichen keys published in *Trail & Landscape* and designed for use by local amateurs. As author or co-author his name appears on numerous publications; 12 major papers, 3 book-length articles, 19 other papers, and 15 reviews (in seven different journals) have appeared since 1961, and more are in process.

The Ottawa Field-Naturalists' Club honours Dr. Brodo as an outstanding scientist, conservationist and field-naturalist.

Dr. Bernard Boivin

Honorary Membership in the Ottawa Field-Naturalists' Club is conferred on Dr. Bernard Boivin, FRSC, a nationally famous botanical taxonomist. He recently retired after many years with Agriculture Canada, during which period he served on Council from 1950 to 1959.

Dr. Boivin was a student of Frère Marie-Victorin. He has been at the forefront of botanical explorations in Canada since the 1940s, when he returned from Australia where he served as a Japanese translator for the armed forces. In addition to taxonomic studies of a number of plant genera, he is the author of several major and important more general works including a five-volume *Flora of the Prairie Provinces* (1967–1981), a definitive floristic treatment of Alberta, Saskatchewan and Manitoba; *Enumération des Plantes du Canada* (1966–1967), a detailed check list of the Canadian flora; and the only comprehensive study of Canadian plant collections *Survey of Canadian Herbaria* (1980).

Dr. Boivin has been a thought-provoking and at times controversial taxonomist who has published prolifically, and has motivated students and associates alike to embark on many studies. As the premier authority on the history of Canadian botany and botanists, he has accumulated a vast body of biographical data. He is currently attached to Laval University, Quebec, where he has taught a course on this subject, and is continuing his botanical research.

The Ottawa Field-Naturalaists' Club is proud to add Dr. Boivin to its group of Honorary Members.

Verna Ross McGiffin

Verna Ross McGiffin of Pakenham has been a

member of The Ottawa Field-Naturalists' Club for more than forty years. Until her move to Almonte, after retirement as an editor with Agriculture Canada, she was a very active participating Ottawa member, contributing her skills, time and enthusiasm to many Club activities. Following service on various committees she was a member of Council from 1950 to 1956, always with constructive and innovative ideas.

She had a deep commitment to share her own enjoyment of natural history with others. During the 1940s, when many young people came to Ottawa for war-time employment, she gave unstintingly of her time, leading field trips for beginners and others, with a friendly and gracious welcome to hesitant newcomers.

It was Verna Ross who recognized the need for a Club Newsletter to serve the many local members who felt themselves remote from the world of professional biologists and the scientific papers of *The Canadian Field-Naturalist*. With Council's approval, she initiated the Ottawa Field-Naturalists' Club Newsletter and served as its first editor.

It was she also who, in the 1940s, suggested that Council authorize the formation of study groups, so that members could pursue special interests with like-minded amateurs. She was thus instigator and a founding member of the Fern Study Group, which evolved into the Trail Study Group, studying the orchids and later the salamanders of the Ottawa area. She was also a founding member of the popular Bird Study Group.

In her Ottawa Valley home village of Pakenham, she was an early participant in the Pakenham Christmas Bird Census, and has taken part in this count since 1926 (1981. *Trail & Landscape* 15(5): 248–253).

She and her sister, Edna, made many interesting discoveries and observations in and around Pakenham, and she generously hosted many a field trip to the area to share these discoveries — geological, zoological and botanical — with The Ottawa Field-Naturalists' Club. Her observations and studies in various fields of local natural history were always carried out with sound regard for scientific accuracy, and earned her the respect of professional biologists.

Since she returned to Pakenham, many of her Ottawa Valley neighbours have benefited from her broad knowledge of local natural history, in the fields of fossils, birds, plants, and also Indian artifacts.

In addition to adding much to our knowledge of the natural history of the Pakenham area, Verna's great contribution has been her unceasing encouragement of amateur naturalists, inspiring and guiding beginners to embark on the study and enjoyment of natural history.

Stewart D. MacDonald

Honorary Membership is conferred on Stewart D. MacDonald, Curator, Vertebrate Ethology Section, Vertebrate Zoology Division, National Museum of Natural Sciences, for his major contributions to knowledge and conservation in the Canadian north.

Stewart's interest has long been centred on the Arctic. Especially is his name associated with the Polar Bear Pass Natural Wildlife Area on Bathurst Island, the first ecological reserve in the Canadian north. Several organizations have been involved in one way or another in this development, but he has been an initiator and a pusher for decisive action since 1968, when a research station was set up in the area. He has used every opportunity to inform others of the site and why it is important that the area not be despoiled by commercial exploitation of natural resources. These efforts culminated in 1982 in the establishment by our government of Polar Bear Pass as the first such reserve.

It was again largely as a result of Stewart's efforts that tiny Seymour Island, 20 miles north of Bathurst Island, was proclaimed a migratory bird sanctuary in 1975. This was due to his recognition of the need to protect the only known (at that time) breeding colony of the rare Ivory Gull in the Canadian Arctic, discovered in fact by him and Dalton Muir.

He was the first to record nesting of Ross's Gull in North America in July 1976, in Penny Strait.

His interests include the study of behaviour in birds and mammals, and he has contributed excellent photographic records. He is aware of the need for good communication between specialists and non-specialists, and has participated in this field through personal appearances, and on radio and TV. This is further exemplified by Stewart's involvement with young people. In 1965–66 he was Chairman of the Macoun Field Club and he has since continued to share his experiences with MFC members, treating them always as fellow naturalists. He has been quick to detect the spark of enthusiasm in students and to give them support and help in advancing their interests. Many were given their first chance to visit the Arctic by Stewart and, whether or not they have continued in the scientific field, this experience has coloured their lives and given them a continuing feeling of responsibility toward this fragile region.

He is one who strives to popularize scientific subjects so that non-specialists can understand and enjoy the information that exists, and see how it may be important from the viewpoints of conservation, of ecological balance, and of understanding natural life around us. Achievement of these goals by scientists like Stewart MacDonald is very important to the suc-

cessful continuation of such studies, and we are pleased to recognize his efforts and accomplishments in our own far north by this Honorary Membership.

Member of the Year Award
Dr. C. Richard (Rick) Leavens

The 1983 Member of the Year Award is presented to Rick Leavens for his extraordinary efforts in connection with the Federation of Ontario Naturalists Annual General Meeting and Conference, held in Ottawa in the spring of 1983.

Rick was involved in virtually every aspect of the planning, organization, and administration of the event. He served on the Organizing Committee, assisted with program development, and provided liaison with Carleton University. At the Conference he helped coordinate the exhibits, erected signs, and acted as a trouble-shooter. He helped field trip participants locate their buses, ensured that buses departed on schedule, checked that box lunches were prepared and distributed, and in general, saw that everything ran as smoothly as possible. Rick also managed to find the time to lead one of the major field trips on the program: a canoe outing on the Tay River.

By many accounts the 1983 FON Meeting and Conference was "the best ever". The event could not have been nearly so successful without the tremendous efforts of Rick Leavens.

With all that, he maintained his usual contributions to the Excursions and Lectures Committee, arranging for leaders and speakers, and buses for selected Club outings. He also serves as general information coordinator for the Committee, assisting with preparation of "Coming Events" in *Trail & Landscape* and arranging for occasional publicity for Club events in the local news media. And he was involved in the organization of the Club Soirée last April.

The Club is fortunate to have members like Rick, who is one of those people always willing to take on that one additional task that needs doing. We are pleased indeed to give him recognition in this fashion.

Service Award
Stephen J. Darbyshire

This award is presented to Stephen Darbyshire primarily for his commitment to the Macoun Field Club. A former member himself, he has been active with the MFC for the past five years, and in 1983 he completed his third year as Chairman of the MFC Committee. Stephen has chaired and led the MFC almost single-handed since assuming the chairmanship. This has required his attendance at meetings on Friday afternoons and Saturday mornings during the school year, in addition to the occasional field trips of one or more days duration.

During this period he has dealt with growing problems of assuring leadership and appropriate meeting and study facilities. He has eloquently laid out for Club executive and Council and the members of the Club, through *Trail & Landscape* and at the Annual General Meeting in January last, the particular problems now facing the MFC.

In addition to his Macoun involvement, Stephen was a Council member for several years, where he made important contributions to the formation of the Awards Committee, to Conservation issues, and to other Club activities. He continues to lead the spring amphibian hunt.

It is a pleasure to recognize these efforts with the 1983 Service Award.

Conservation Award
Ernest A. Beauchesne and **Donald G. Cuddy**

The fight to preserve the Alfred Bog has been a dominant activity of The Ottawa Field-Naturalists' Club over the past year and a half, and continues to be so. Many individuals have made important contributions to the efforts to date — but none more than Ernie Beauchesne and Don Cuddy, 1983 recipients of the Club's Conservation Award.

The whole issue would simply have died had Ernie not come on the scene when he did. It was he who encouraged, cajoled and propelled the OFNC into becoming involved in the useful and instructive Ontario Municipal Board hearing in May 1983, and it was he who made the preliminary arrangements for the first purchase of land from the Alfred Bog Trust Fund. Representing the VanKleek Hill Nature Society he was the "Man on the scene" with first hand knowledge of the bog and its nature. He played a major role in rallying public support and raising media focus for our joint endeavours to preserve the bog, and his efforts continue.

Don Cuddy, on the other hand, provided low profile technical and logistical support that was equally invaluable. It was Don who marshalled the known life science data and presented them objectively and expertly to the media, to supporters and to the OMB hearing officers. His excellent article, "Alfred Bog" *Trail & Landscape* 17: 147 became the technical basis for many T.V., radio and newspaper interviews and was a persuasive argument for the need to protect the bog. Don also led excursions into the area, prepared displays, briefed supporters and provided vital advice to all concerned throughout the critical OMB period, and was a valuable fund raiser.

For any successful conservation endeavour there are obvious needs: enthusiastic, energetic and highly motivated people on-site, and an objective, competent foundation of data, management options, planning

principles and commitment. The Ottawa Field-Naturalists' Club is pleased to recognize the outstanding efforts of Ernie Beauchesne and Don Cuddy in these aspects, and we owe them a great vote of thanks.

The Anne Hanes Natural History Award
Bruce M. Di Labio

The Anne Hanes Natural History Award is presented to Bruce Di Labio in recognition of his interest, diligence and expertise as a birder and as a recorder of what has been seen in the Ottawa Area and other localities of interest to the members of The Ottawa Field-Naturalists' Club. A prolific contributor to *Trail & Landscape*, he records compilations of results of trip and special count projects, and presents his personal findings and those of others. This important practice ensures the availability of such records for present use and for the future. In addition to these records, many of which contain new data on sightings and occurrences in the area, Bruce, both alone and with others, has published records of specific unusual events — the Gray Kingbird, an albino Spotted Sandpiper, the over-wintering Sandhill Crane, a rescued Saw-whet Owl, the Barrow's Goldeneye at Champlain Bridge, and recently the sightings and records of Northern Gannets in our area. The September-October (1984) issue of *Trail & Landscape* contains an article giving detailed records on local sightings of Great Gray Owls last winter.

As well, Bruce contributes routinely to *The Shrike*, to *American Birds* of which he is Regional Sub-editor, and to The Citizen bird column. He has participated in the Canadian Wildlife Service shorebird migration monitoring program, and in development of the Ontario Breeding Bird Atlas, both activities requiring careful observation and much field time.

Bruce is well known for his interest and availability to introduce out-of-town birders to our area, and for assisting in events and programs of the Ottawa Field-Naturalists' Club, the National Capital Commission, the Canadian Nature Federation, as well of course of the National Museum of Natural Sciences. The value and effect of his observations of birdlife are increased by these various contacts, which lead to exchanges and sharing of knowlege.

The assembling of observational and interpretative data for permanent records on the current distribution of bird species provides the necessary building blocks from which patterns of life history, movements and changes are built up across the country.

W. K. GUMMER

and the members of the Ottawa Field-Naturalists' Club Awards Committee.

Erratum: Volume 98, number 2: Aiken and Darbyshire page 249

In 98(2): 249 — The morphology of a vegetatively proliferating inflorescence of Kentucky Bluegrass, *Poa pratensis* BY S. G. Aiken and S. J. Darbyshire — the superscript [2] after Darbyshire should have been [1]. His correct address is Biosystematics Research Institute, Agriculture Canada, Wm. Saunders Building, Central Experimental Farm, Ottawa K1A 0C6.

FRANCIS R. COOK
Editor

A Tribute to ROBIE WILFRED TUFTS, 1884–1982

W. EARL GODFREY

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The death of Robie Wilfred Tufts on 7 November 1982 in Wolfville, Nova Scotia, in his 99th year, marked the close of an era in natural history and conservation circles throughout and beyond the Maritime Provinces. Pioneer in the interpretation and enforcement of the federal migratory bird laws; fluent writer of books, articles, and essays on birds; inspiration and career-maker of many a young bird student, he reached and influenced many people in all walks of life. For over half a century he was the chief spokesman for bird welfare in the Maritimes, his name synonymous with the rightness of the conservation principles he so ably supported.

Robie Tufts was born on 11 August 1884 in Wolfville and he lived his entire long life there. His father, Dr. John Freeman Tufts, was Professor of Economics and Political Science at Acadia University and sometime Principal of Horton Academy. His mother, Marie Woodworth Tufts, was principal of Acadia Ladies' Seminary, a botanist, and a connoisseur of literature. Thus, from his parents, Robie inherited an aptitude in the natural sciences, in the effective use of words, and in practical affairs and money management, all of which were to stand him in good stead.

As happens often in the careers of successful naturalists, Robie's interest in nature was early acquired. While he and his older brother, Harold, were still young children, they were introduced to field work by their mother who took them on local plant collecting trips. In the meadows, marshes, and wooded hills surrounding Wolfville the innate interest of the two brothers flourished and soon focused irrevocably on birds.

As was the custom in those days, the collecting of birds' eggs was high in their priorities and they collected also a small number of birds for scientific purposes. They kept meticulous records of their observations and were unusually skilful in the preparation of bird specimens. Thus the brothers grew into manhood, both of them keen and competent ornithologists.

Salaried careers in ornithology in those times, however, were few and hard to come by. Consequently Harold turned to dentistry and set up a successful practice in Boston, Massachusetts, where he lived until his retirement. Robie, who disliked living in a large city, remained in Wolfville and, on completion of his education at Acadia University, entered the world of finance with the local branch of the Bank of Montreal. At the bank, his shrewdness in money management stood him in good stead although his interest in birds remained always paramount. He spent as much of his spare time as possible observing the local birdlife and eventually published an unusually well-written and accurately documented annotated list of the birds of the Wolfville region (Tufts 1917).

It became a matter of increasingly deep concern to Robie that the numbers of many birds, particularly game birds and the birds of prey, were steadily declining due to overshooting and the lack of effective game laws. He followed eagerly progress of consultations between Canada and the United States on the drafting of continental laws designed for the protection of migratory birds. When the Migratory Birds Conservation Act, the enabling legislation under which Canada was to carry out her commitments, was drawn up in 1918, Robie left his position with the bank and applied for one as a district administrator under the new Act. In 1919, he was appointed the first Chief Federal Migratory Birds Officer for the Maritime Provinces, charged with two primary duties: education of the public in bird conservation and the enforcement of the bird laws.

Armed with a pioneer's conviction of the rightness of the new laws and with the enthusiasm, energy, and fearlessness to enforce them, he lost little time in taking up his new duties. He travelled widely throughout the Maritimes, meeting with the leading bird hunters and organized sportsmen. He lectured to adult audiences in the evenings and visited schools by day. He was remarkably successful in enlisting support. Still there were many who openly rebelled against the new restrictions on their hunting, some of them violent and dangerous; but that never deterred Robie as he proceeded to enforce the laws impartially and vigorously — indeed too vigorously by some standards! His guidelines were to "hew to the line and let the chips fall where they may". He followed those guidelines to the letter. As he (Tufts 1975) explains it:

"During the first 13 years — 1919 to 1932 — we recorded 679 convictions, so many in fact that (according to an admission latterly received from one of my superior officers) the top brass in the political arena in Ottawa were so bothered by complaints that kept coming in from local Members whose party supporters at home had run afoul of the bird-laws and been fined, that in 1932 all of my full-time assistants were fired. As for myself, I was instructed to stop the law enforcement activities and in future to act as liaison officer with the R.C.M.P. who from then on

Robie Tufts, Chief Federal Migratory Birds Officer for the Maritime Provinces.

would enforce the *Migratory Birds Act*."

No matter, by that time Tufts has broken the backbone of resistance to the bird laws and had accomplished the general acceptance of the Act.

He was by no means ruthless in his treatment of law-breakers unless such treatment was well deserved. Indeed, he was extremely sensitive to the spirit of the law and to the intent of the law-breaker. It is well known that on more than one occasion he paid out of his own pocket the fines of persons who technically broke the law but did so under extremely extenuating circumstances. He was forever looking for the good in people and he often found it. As one of many examples, the first caretaker of the Seal and Mud Islands Bird Sanctuary, appointed on the basis of Robie's recommendation, was a man whom Robie had formerly prosecuted for illegally taking wild bird eggs from a large tern colony there! Robie correctly read his character and the man faithfully performed his caretaker duties for the rest of his life.

Dr. Tufts enjoyed helping deserving people and few there were who came to his door who were turned down. Often when he had no work for them he invented some. He derived particular pleasure from encouraging and helping serious young bird students, and through him the small town of Wolfville produced undoubtedly more native sons who successfully found ornithology-oriented careers than any other town of its size in the country! He had an amazing ability, unique in my experience, to inspire so much enthusiasm for the work that it transcended all obstacles and the inevitable disappointments. He wisely instructed his protégés in the fundamentals of ornithology and impressed on them the necessity of a formal education. Once convinced that his protégés showed real promise, he was tireless in searching for a job opening for them, anything that could give them a start. He had many influential contacts who highly respected his judgment and his success in finding foothold employment for his protégés was truly outstanding. Therein lies another of his major accomplishments, for his students went on to hold positions, including some of the highest, in museums, universities, wildlife management organizations, and other institutions in both Canada and the United States.

A fine figure of a man, tall, slim, quick, handsome, and charismatic, he immediately created a favorable impression in people of all ages and both sexes. This certainly was an important ingredient in the success of his career. He possessed tremendous energy and was inclined to run as often as he walked. He did just about everything well. He invariably went far in tennis tournaments for many years and he was the best wingshot I ever hunted with. He was an excellent woodsman with an uncanny orientation ability. In specimen preparation he was a perfectionist. He wrote easily and well, and as a story teller he could hold an audience for hours.

When I was a boy in Wolfville, it was a red letter day when he took me afield with him. At no time did it ever occur to me to doubt for a moment his ability to cope with any difficulty we encountered whether it was handling a canoe in roughest water, maintaining a walking course through the most confusing terrain, or rounding a hairpin turn in the road at something well in excess of the speed limit! Indeed we boys looked up to him as a sort of Superman and I guess he was.

For many years an evening of poker with several friends, each of whom took his turn at hosting the game, was a favorite relaxation. When conferences took him to Ottawa, there was sure to be a poker session which included Robie, the Hoyes Lloyds, P. A. Taverner, and others. Although the stakes were low, rivalry ran high over the years. As Taverner (*in litt.* to W. L. McAtee, 4 June 1929) expressed it,

Robie Tufts at his wilderness cabin at Lumsden Lake, Nova Scotia.

"Robie Tufts of Nova Scotia has been here for a week or so and there have been some wild poker nights. . . . I was lucky enough to escape the worst that broke up at 4 a.m. and I think I broke about even, but there was some weeping and wailing and a smile on the face of the tiger."

As an oologist, he often found it necessary to climb trees. He was injured by falls several times but this never restrained him. Once while recovering from one such serious mishap he saw fit to hire a telephone linesman to climb a formidable tree. When the linesman saw the tree, he took one glance at it and refused. Robie borrowed the man's climbing irons and climbed the tree himself despite his injury.

Dr. Tufts had a passion for fireplaces and he had a way with them. He could quickly transform the sullenest of embers into a crackling fire, one of the charms of his study. Up almost until his last summer, he harvested firewood with chainsaw and axe, and his spacious basement bulged to the ceiling with cords of it. As Don Crowdis, a longtime associate of Robie's, observed, "He had a truly great talent for friendship and his fireside warmed the great and the small, the scholar and the player of games, the rich and the not-so-rich. Enough wood went into it to rebuild Wolfville and enough living went on in that study to fill several lives."

It is my own good fortune to have known Dr. Tufts for most of my life. Although I was a boy when I first met him, every detail of that meeting is as clear as though it happened yesterday. It was in April and there were birds in the bare branches of a Wolfville apple orchard. Another boy and I were taking practice shots at the birds with our homemade slingshots when suddenly an impressive figure dashed up, seemingly out of nowhere. He introduced himself as Robie Tufts, promptly confiscated our slingshots, and severely reprimanded us. Just when we were contemplating the prospect of a lengthy period in some reformatory, his voice softened and he instructed us to appear at his office at a later date.

At the appointed time, days later, we were at his doorstep. We were pleasantly welcomed by Dr. Tufts into the most intriguing office I ever encountered. There were paintings of birds by famous artists, cabinets of mounted birds far more beautiful than I ever imagined mounted birds could be, shelves of bird books, a warm and redolent fireplace. In that enchanted setting, the Robie Tufts enthusiasm and charm quickly converted two misguided boys into lifelong conservationists. That was my introduction to the treasured friendship of Robie Tufts, a friendship that was to grow and endure and become a never-failing source of inspiration, guidance, and freely-given help of all kinds for over half a century.

Dr. Tufts officially retired from the Canadian Wildlife Service in 1947, after 28 years with that organization. His bird work continued unabated but now with greater emphasis on writing for publication. He contributed articles and notes to various scientific journals, especially *The Canadian Field-Naturalist*, and for many years his popular newspaper column entitled "Woods, Water and Sky" appeared weekly in the *Halifax Chronicle-Herald*. In 1972, he combined a selection of these newspaper essays into a book entitled "Birds and Their Ways". Other books from his pen include "Looking Back", which appeared in 1975, a well-written narrative of 15 of his exciting experiences as a migratory bird officer. In 1978, he published "Nova Scotia Birds of Prey". Most successful of all was his authoritative book "The Birds of Nova Scotia" in which he brought together the fruits of a lifetime of observation and record-keeping. The first edition appeared in 1962 and it was followed in 1975 by a completely updated new edition. Both editions were quickly sold out and are now collector's items.

Robie Tufts in his garden at Wolfville, Nova Scotia, 23 July 1967. Photographed by W. E. Godfrey.

Well deserved recognition came abundantly in later

years. He was the recipient of honorary doctorate degrees from Acadia and Dalhousie universities. The laboratory of ornithology at Acadia University was named in his honor. A bird, a subspecies of the Long-eared Owl *Osio otus tuftsi,* bears his name. He was an Honorary Member of The Ottawa Field-Naturalists' Club. In addition, he was the first president of the Nova Scotia Bird Society, and he held high official positions in the Nova Scotia Fish and Game Association and other wildlife organizations.

Surviving are his wife, the former Lillian Thompson and one daughter Virginia (Mrs. Allison D. Pickett), Deep Brook, Nova Scotia. He was predeceased by his first wife Evelyn, a sister Hilda, and a brother Harold.

Publications of Robie W. Tufts

Compiled by W. E. GODFREY

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1922c. Early nesting of the American Goshawk. Canadian Field-Naturalist 36(5): 98.
1922d. Willet census in Nova Scotia. Canadian Field-Naturalist 36(8): 152–153.
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Book Reviews

Zoology

The Life of the Hummingbird

By Alexander F. Skutch. 1973. Crown Publishers (Canadian distributor General Publishing, Don Mills). 95 pp., illus. U.S. $15.95; Cdn $22.50.

For someone interested in a general, non-technical yet authoritative treatment to this complex and fascinating group of birds, this is it. Written by the "Audubon of Central America" (as Roger Tory Peterson so aptly described the author), the text moves with the smooth, clear and exact flow that we have come to expect from Alexander Skutch. He expertly presents an accurate and dependable review of the published literature and of his own perceptive observations so effortlessly as to make this seem as much a work of art as science. That impression is greatly enhanced by Arthur Singer's illustrations. His drawings of almost 90 species of hummingbirds not only are stunning visuals in their own right but beautifully illustrate the major points of the text.

Skutch covers all the bases in assessing the major facets of hummingbird ecology. Chapters covering flight, metabolism, bill and tongue structures, nesting behaviour (and much more) are followed by a concise and highly useful selected bibliography and a complete index to the 109 species mentioned in the text —about a third of the known hummingbird species.

Although it was published over ten years ago, this economical, attractive and virtually error-free book remains a wonderful introduction to hummingbirds. I highly recommend it.

Daniel F. Brunton

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The Birds of British Columbia (11) Sparrows and Finches

By C. J. Guiguet. 1983. British Columbia Provincial Museum Handbook No. 42. vi + 142 pp., illus. $2.00.

For many years the Provincial Museum in British Columbia has been publishing a low cost handbook series designed to introduce various floral and faunal groups to the general public. Director Yorke Edwards attributes nine previous titles in the series to Charles Guiguet, but if one adds two that Guiguet co-authored with I. M. Cowan and G. C. Carl, this becomes his twelfth contribution to the series.

The current volume encompasses birds of the family Fringillidae, the sub-family Emberizinae and the family Ploceidae (House Sparrow). While the text was written primarily before North American ornithologists divided the old Fringillidae, the grouping of these birds in one volume is still more logical in a book designed for the beginner than a book on forms believed to be more closely related would have been. Inclusion of the House Sparrow suggests that the present grouping would have been followed in any case. The English species names have been updated. Latin names are excluded, in keeping with the targeted audience, but oddly comments on races are included in most species accounts. While easily distinguished races, such as the juncos, towhees, White-crowned Sparrows, and rosy finches deserve an introduction to even the beginner, I question the value of discussing races of Song or Fox Sparrows with novices. The habitat difference between Brewer's Sparrows of the sagebrush areas and the "Timberline" race of high altitudes is of particular interest to British Columbia, and thus well worthy of mention.

Each species found regularly in the province receives a two to three-page account, divided into sections on description, range and variation, voice, nesting, food, and migration. These are based partly on the literature and partly on records on file at the museum. Species not normally found in British Columbia are covered in one or two paragraphs on description and provincial records.

Guiguet's accounts are written well and provide an excellent introduction to the species covered. The accompanying illustrations by Keith Taylor vary in quality, but all represent the features of plumage well and on the whole they enhance the text. The text contains only three actual errors. The Dickcissel has been reported in south-central Saskatchewan as stated, but is hardly regular there as implied. Godfrey (1966) is mistakenly printed as 1968 on pages 76 and 80, and the reference to Laurence's Goldfinch on p. 112 should have been spelled Lawrence's. A few omissions are unfortunate. In a text frequently discussing races, I thought that no mention of hybrids between Black-headed and Rose-breasted Grosbeaks was odd, although I am not aware of any records to date in

British Columbia. One of the songs of the spotted race of the Rufous-sided Towhee is described well, but this race has at least two distinct songs and both songs differ markedly from that of the eastern race. Lack of mention of the catbird-like call of this species is perhaps more serious as this call often first alerts birdwatchers to the presence of the bird. There are more coastal records of the Swamp Sparrow than indicated, as summarized by Weber et al. (*Discovery* n.s. 9: 28–29, 1980; *Murrelet* 63: 96, 1982). Although redpolls are not easily distinguished, there are better clues to identity than the vague references to the lighter colour of the Hoary.

The book ends with a short list of references, including publications on some of the rarities, but excluding several other similar papers.

Guiguet is to be congratulated in completing yet another of these fine handbooks and the museum deserves the hearty thanks of western naturalists for continuing this excellent series at such affordable prices.

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Acta Ornithologica

Acta Ornithologica is published several times a year by Instytut Zoologii Polskiej Akademii Nauk, Stacja Ornitologiczna. Although the journal has been in existence since 1933 it has had an uneven publication history with several interruptions. In recent years it has been restored and is now becoming more well known and widely circulated. It publishes original research on birds in English or Polish on a broad range of subjects including field observations, museum studies, migration, and community ecology.

A recent issue (Volume 19: 1–6, 1983) contains a number of articles of interest to North American ornithologists. Maciej Luniak describes a 20-year study on the avifauna of urban green areas and makes suggestions for the management of parks, cemeteries and other urban allotments for birds in both summer and winter. The ecology of arboreal birds is discussed in two related articles: one by Piotrowska and Wolk on the breeding avifauna of coniferous forests, and the other by Lewartowski and Wolk on the breeding avifauna of moss-spruce forest and related habitats. Both papers are based on long-term studies in Bialowieza Primeval Forest. Papers on local bird distribution and on the banding and migration of both dunlin (*Calidris alpina*) and buzzards (*Butes buteo*) round out the issue. Acta Ornithologica is available from ORPAN Export, pok. 1611, PKIN, 00-901 Warszawa, Poland for about $20.00 U.S. per annum.

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The Snake Book

By Roy Pinney. 1981. Doubleday, Garden City, New York. 248 pp., illus. U.S. $12.95.

As a person who daily works with snakes, and who, almost as frequently, is called upon to dispell myths, ally fears, and convince the general public that these terribly misunderstood animals are beneficial, I have long hoped for a book which would present snakes in a favourable and non-sensational manner. This book does fill a gap in popular literature, and I would like to recommend it without reservation; however, that is not possible.

The book does offer some insights into the world of snakes for the novice snake fancier or the armchair naturalist. It is reasonably priced and contains numerous black-and-white photographs of a variety of snakes. However, the text and the organization of the book leave a great deal to be desired. There are a number of statements which could be misconstrued by the layman, for whom this book was intended, and for whom it will have the greatest appeal. To the professional herpetologist, this volume is probably of little value other than entertainment, and the errors which periodically surface will be ignored by these individuals.

The author has a penchant for multi-syllable words and compound sentences, whereas a simple statement using simple words, in a clear style would not only suffice, but would make more sense to the reader. He has a very annoying habit of introducing scientific terminology into the text, pages before he defines

these terms. There is no glossary — a tremendous failing in any introduction to a subject. The author's over-all writing style is rather inconsistent. Many of the sections are straight forward and free flowing when read. Others are far too poetic for this subject and rather obtuse in their readability. (They would be more appropriate in a Harlequin Romance). He, at times, seems to have become befuddled by the language and makes mis-statements which were missed by the proofreaders.

The author frequently makes very generalized statements, such as: [page 138] "More [people] die from the bite of a bee, wasp, or hornet than from a venomous snake. Even poisonous spiders contribute twice as many fatalities as snakes. The odds are literally greater of being killed by lightning!", without giving any indication of where he obtained his data. I have serious doubts as to the validity of some of these statements, and I worry that the uninformed reader will accept them as truth. On page 154, he states, "A study done for the World Health Organization estimated that there were 30,000 to 40,000 deaths annually from snakebites." If this is true, his previous statement would indicate that between 60,000 and 80,000 people die annually from spider bites, and that more than 30–40,000 people are killed by lightning. These figures seem a bit unbelievable to me; the author does not cite a reference so that the reader may investigate.

In several instances, the author contradicts himself later in the text. For example, on page 173, he states that the bite of a sea snake "is relatively painless . . .", and then, on page 180, he states, also about sea snakes, "While the bites are rarely fatal, they are extremely painful." There are some errors in the book which we can put down to typographical or spelling mistakes, but there are at least two photographs misidentified. The photo on page 117 is labeled as an Anaconda (*Eunectes murinus*) of South America. In actuality, it is a White-lipped Python (*Liasis albertisii*) from New Guinea. The photograph on page 205 is identified as an Amethystine Python (*Liasis amethystinus*) (the spelling of the specific name should be *amethistinus*) which it certainly is not. It is most likely a Black-headed Python (*Aspidites melanocephalus*).

The book opens with a chapter on "famous" herpetologists. It is interesting and entertaining reading, but the author's choice of people to so honour is a bit strange. Three of the ten herpetologists [sic] included were (or are) not herpetologists, but showmen and entrepreneurs. I strongly felt that this book required more of a conservation base, and including these users of wildlife was a poor choice. There follow chapters on Physiology, Snake Behavior, Snakes in Captivity, Venomous Snakes, Men Versus Snakes, and Opportunities in Herpetology. I enjoyed the chapter entitled, "Men versus Snakes" perhaps more than any other as it dealt with superstition, folklore, and historical beliefs about snakes. At the beginning of the chapter on Snakes in Captivity, the author indicates that he will discuss the breeding of two species of snake, and appropriately has two sub-headings dealing with those species. However, he only details the breeding of one species, not the other. He devotes an entire chapter to poisonous snakes, but does not give equal time to the non-poisonous taxa, which are more numerous and diversified.

I believe this book is an honest attempt at presenting a relatively misunderstood subject, and one with limited popularity, to the general public. However, because of statements which can easily be misconstrued by the layman, errors and unsubstantiated generalizations, I cannot whole-heartedly recommend it.

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Bibliography of the genus *Phalaropus*

By Sven Blomquist. 1983. Volume 4. Ottenby Bird Observatory, Dogerhamn, Sweden. 394 references. U.S. $4.

Bibliography of the genera *Calidris* and *Limicola*

By Sven Blomquist. 1983. Volume 3. Ottenby Bird Observatory, Dogerhamn, Sweden. 1364 references. U.S. $7.

These two new bibliographies on wader birds are now available from Sweden. They provide coverage of the international literature on the three genera up to 1980.

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BOTANY

Plants of Essex County: A preliminary list

Compiled by Wilfred Botham. 1981. Essex Regional Conservation Authority, Essex, Ontario. xiv + 223 pp. Limited edition. $5.95 plus $2.55 postage.

Jutting into Lake Erie, Essex County is the southernmost county in all of Canada. Widely known among amateur naturalists and visitors to Point Pelee National Park as a good spot to see migrating birds and butterflies, it also boasts a large and diverse flora which is unique in Canada. Southern species such as Swamp White Oak, Pin Oak, Sassafrass, and Big Shellbark Hickory, characteristic of the Carolinian forest zone, are relatively common. Several plants are found nowhere else in Canada. In addition to its Carolinian flora, Essex County is also home to a number of plants which normally grow on the tall grass prairie.

The native flora is disappearing. Essex County is one of the richest farming areas in the country. The prairie habitats are threatened by the urban expansion of Windsor. The county has suffered the loss of many native plant species. Ninety-three species of vascular plants reported in 1914 have not been recorded since. Two hundred and fifty-four vascular species found in Essex County (or approximately one-quarter of its vascular flora) are considered rare or endangered in Ontario. It is therefore most fortunate that the Essex Region Conservation Authority has sponsored this list.

Scientific names follow those used in Scoggan's *Flora of Canada* for the most part. Where they differ from Scoggan's classification the synonymy is given. Species are arranged on the Engler-Prantl system familiar to most users of the two principal floras used in Ontario — Britton and Brown, and Gray's.

Listed by scientific name, each species is, where possible, assigned a common name and is listed as native or introduced. Collections of the species are well documented with citations of herbarium specimens and literature records. Many of the early records of plants in Essex County were made by Charles Dodge. Question is cast upon some of the species reported by Dodge. Many were based on sight records alone, and have not been collected since; so the documentation is a welcome addition. Botham also provides flowering dates for many species, and notes that this will probably be the book's most popular feature for local plant observers. The distributions of species within Essex County are given in a code which refers to townships or to areas of special interest.

The list of vascular plants is supplemented by limited lists of bryophytes, fungi and lichens, and by references which, for the most part, deal with aspects of the flora of this the southernmost part of Ontario.

Given the vagaries of taxonomy of some groups combined with the fact that the publication of a checklist invites its own correction, it takes a certain conviction or courage to publish such a list. Indeed a page of Errata supplied with the current edition shows that revision is already in progress. Botham must be lauded for his efforts.

This checklist will certainly direct the attention of both residents and visitors to the diversity of the flora of this unique area of Canada, and will be useful to phytogeographers and to botanists, both amateur and professional, concerned with the flora of southern Ontario.

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Flowers of the Wild: Ontario and the Great Lakes Region

By Zile Zichmanis and James Hodgins. 1982. Oxford University Press, Don Mills, Ontario. xv + 272 pp., illus. $35.

The commonest media for botanical illustration are the line drawing and the colour photograph. Each medium has advantages not found in the other. The line drawing provides detail for identification not attainable with the limited depth of field found in a photograph. But the colour photograph often captures the distinctive "look" of a plant in its natural habitat. In *Flowers of the Wild*, Zichmanis and Hodgins have successfully combined both media, presenting a selection of Ontario wildflowers illustrated in 127 pairs of plates.

The buyer should not feel constrained by the geography implied by the subtitle. Nearly half of the species presented occur through most of Canada. Three-quarters of them can be found in most parts of Eastern North America. Nor should the buyer be misled into thinking that these are all native plants. About four-fifths of them are native, but the book includes a dozen or so naturalized European and Eurasian species which can be found on almost any roadside or waste place.

The plates cover approximately 130 species from 61 families. The selection is representative of the commoner or more distinctive plants of Ontario. In some respects it is reminiscent of the selection one might find in an undergraduate course in plant taxonomy. There are no woody plants. While the grasses and sedges have been omitted, a few distinctive grass-like monocots have been included.

Zichmanis is an illustrator of no mean competence. Her elegant habit sketches and colour photographs invariably capture the essence of the species and will earn this book a place on many coffee tables.

Hodgins' text, which accompanies the plates, is eclectic, providing notes on the horticulture of these wild plants, and on the etymology of their scientific names, as well as diagnostic features used to verify the identification. For each species the geographic range and season of flowering is also given. For many species, additional notes are given if the plant is known to be eaten by or pollinated by a particular animal or insect. For each species illustrated, a list of similar species is offered with notes on how to distinguish the similar species from the one illustrated. For many species, references are given to scientific articles dealing with their taxonomy, horticulture, or ecology.

The plates are organized by English common name. The usefulness of this organization is questionable. While a common name is often the easiest way to remember a plant, it is not always the quickest way to find it in a book. A systematic arrangement of plants by their families at least tends to bring together plants which look similar, making comparisons easier. Given the organization of the book by common names the authors should not have listed similar species by Latin name only. This necessitates consulting the index to discover if the similar species is even shown in the book.

The text is informative and appears to be generally accurate. One might ask though if there are really only two species of St. Johnsworts in all of Ontario. Hodgins appears to be a bit of a purist in the matter of Greek etymologies. His choice of the Greek form *aner* instead of *andros* to explain the derivation of the generic name *Peltandra* is confusing. While the Greek word *glaukos* does mean bluish-grey, the botanical term glaucous means white or whitish, as in *Picea glauca*, the White Spruce. To suggest that *Parnassia glauca* or *Zygadenus glaucus* are so named for blue-grey leaves they do not have rather than for white flowers which they do have is spurious.

Appended to the plates are a glossary of botanical terms, a list of Ojibway and French plant names, a selected bibliography, and indexes to the plates by both scientific and common name. The list of Ojibway names provides some nuggets of insight, such as the name for chicory which translates as "white man's soup".

This book will probably be of greatest use to those people with little experience in recognizing wildflowers. As an identification guide it is not exhaustive, but it provides an excellent starting point for the beginner. The excellent quality of the illustrations will doubtless guarantee it an even wider audience.

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MISCELLANEOUS

Canadian Arctic Recollections: Baffin Island 1923–1931

By J. D. Soper. 1981. Mawdsley Memoir 4. Institute for Northern Studies, University of Saskatchewan, Saskatoon. xiv + 141 pp., illus. $20.

In *Canadian Arctic Recollections*, J. Dewey Soper recalled his travels and biological studies in southern Baffin Island between 1924 and 1931. He recorded the various factors which spawned his curiosity about the Arctic; described his first visit to Greenland, and Ellesmere, Devon and Baffin Islands; and then continued with his four years of extensive research and exploration. While relating the events of those years, Soper detailed many of his biological observations. He also elaborated on the physical, cultural and historical settings. The well-measured detail of the observations, events and dates obviously came from Soper's extensive field notes.

No serious technical or typographical problems were found. However, editorial notes could have been used to up-date some technical information. For example, the ringed seal of Nettilling Lake, which Soper indicated as the subspecies *Phoca hispida soperi*, is no longer recognized as a separate subspecies. Another flaw is a lack of the standardized Roman orthography for many Inuktitut words. A glossary by R. G. Williamson provides some of Soper's spellings with the corresponding standardized orthography and English translations, but only place names are given.

Soper sometimes described the Inuit, wildlife or land using the present tense. However, the reader should remember the fact that his perspective is now dated by over 50 years. Nevertheless, Soper repeatedly indicated his esteem for the skills, knowledge, endurance, humour and friendship of the Inuit hunters and their families. He devoted an appendix to his perceptions of the Inuit and another to those of the Eskimo dog.

Over 50 of Soper's drawings illustrate the landscape, human habitations and tools, mammals, and flora. Two appendices list the mammals and birds of the eastern Arctic. The captions for some drawings include Latin species names which are not in use. Also some species are illustrated which are not found in the region. The reader should refer to the species lists, if in doubt.

The publication lacks a map showing the many place names from Soper's first Arctic voyage and his shorter trips in south Baffin. On the other hand, an excellent fold-out map shows most locations visited during his longer expeditions. Having followed parts of the same routes with modern equipment, I admire Dewey Soper's endurance and diligence, and that of his Inuit co-workers.

Although the wildlife and spectacular grandeur of south Baffin may not always be vividly described, Soper's awe, respect and enthusiasm for the wildlife, people, land and climate are contagiously portrayed. Set within the adventures of a pioneering researcher; this is an educational and absorbing natural history of south Baffin during the early 20th century. J. Dewey Soper died in the fall of 1982. I am grateful that he had time to write *Canadian Arctic Recollections*, in addition to his earlier publications (which are listed in the bibliography).

Who should read this book? Simply anyone with an interest in the eastern Arctic: any biologist working in south Baffin; the anthropologist or sociologist interested in the vast cultural changes since the 1920s; the naturalist or layperson looking for an educational adventure story; and possibly the Inuk interested in wildlife distributions and hunting of over 50 years ago.

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The Manual of Outdoor Photography

By Michael Freeman. 1981. Ziff-Davis Publishing, New York. 223 pp., illus. U.S. $14.95.

The objective of this book, as stated by the author, is to provide a working manual to outdoor photography that can be used in the field rather than remaining on the bookshelf. Currently, many works of weighty stature exist on photography in the outdoors; few can actually be directly used in a field situation and subsequently have drawbacks in terms of practical use. Freeman embarks on this endeavor by providing the reader with discussion of five major considerations for taking photographs. These are: 1) light, 2) film, 3) cameras and equipment, 4) subjects and 5) preparations.

Lighting is perhaps the outdoor photographers most useful but difficult tool. Lighting can potentially add more to an outdoor photograph than any other photographic component, however unwanted or unpredictable light can be disastrous. The author gives a logical and well written presentation on lighting factors in photography. What is particularly useful about the discussion is the scope of topics covered and the conciseness of the presentation.

Unfortunately the presentations on film and cameras and equipment are not as useful. Too much detail is given in areas germane to outdoor photography but not useful in the field. For example, the lengthy treatise of camera types and handling is not warranted for a field manual. The photographer must have a good preconception of his/her equipment needs and functions prior to field excursions. Making an image in the outdoors while referring to a guide on equipment is a very difficult task.

The discussion on photographing subjects is a concise summary of various standard techniques for creating good images in the outdoors. Special consideration is given here to basic subject composition that will provide the photographer with a quick reference to a wide array of subject situations.

The final chapter on field preparations is, in my opinion, of limited utility. The majority of the information on travelling with photographic equipment will be common knowledge to all but the very novice photographer. Furthermore, the techniques outlined for packing equipment for a field excursion do not consider specialized photographic outings.

Unfortunately the author has strayed from his objective within the body of the text. The inclusion of information not considered to be appropriate for field use is in my opinion detrimental to the book. I would recommend review of the sections on lighting and subject composition, however these could be read in the indoors and the knowledge taken to the field.

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NEW TITLES

Zoology

Acoustic communication in birds, volume 1: production, perception, and design; and volume 2: song learning and it's consequences. 1983. Edited by Donald E. Kroodsma and Edward H. Miller. Taxonomic editor Henri Ouellet. Academic Press, New York. 360 pp., and 392 pp. U.S. $39 and U.S. $42. Set price U.S. $70.

*__Amphibians and reptiles of New England: habitats and natural history.__ 1983. By Richard M. DeGraaf and Deborah D. Rudis. University of Massachusetts Press, Amherst. 112 pp., illus. Cloth U.S. $14; paper U.S. $6.95.

Animal cognition. 1984. Edited by H. L. Roitblat, T. G. Bever, and H. S. Terrace. Proceedings of a conference, New York, June, 1982. Erlbaum, Hillsdale, New Jersey. XVI + 682 pp., illus. U.S. $49.95.

The arctic skua: a study of the ecology and evolution of a seabird. 1983. By Peter O'Donald. Cambridge University Press, New York. xvi + 324 pp., illus. U.S. $49.50.

Arctic wildlife. 1984. By Monte Hummel. Key Porter Books, Toronto. 160 pp., illus $29.95.

†**Avian use of forest habitats in the Pembina Hills of northeastern North Dakota.** 1983. By C. A. Faanes and J. M. Andrew. Resources Publication 151. U.S. Fish and Wildlife Service, Jamestown, North Dakota. 24 pp. Free.

The biology of butterflies. 1984. Edited by R. I. Vane-Wright, P. R. Ackery, and P. J. DeVries. Academic Press, New York. c360 pp.

†**Biology of the peregrine and gyrfalcon in Greenland.** 1984. By William A. Burnham and William G. Mattox. Commission for Scientific Research in Greenland, Kobenhaun. 25 pp., illus. Dkr. 46.75.

Cephalopod life cycles, volume 1: species accounts. 1983. Edited by Peter Boyle. Academic Press, New York. 516 pp. U.S. $120.

†**A check list of the families and genera of North American dinosaurs.** 1984. By D. A. Russell. Syllogeus 53. National Museum of Natural Sciences, Ottawa. 35 pp., illus. Free.

†**A distributional atlas of records of the marine fishes of arctic Canada in the National Museums of Canada and Arctic Biological Station.** 1984. By J. G. Hunter, S. T. Leach, D. E. McAllister, and M. B. Steigerwald. Syllogeus 52. National Museum of Natural Sciences, Ottawa. 35 pp., illus. Free.

†**Eagles fly free.** 1984. By Chris Mellish. Vantage Press, New York. 112 pp. U.S. $7.95.

Fish reproduction: strategies and tactics. 1984. Edited by G. W. Potts and R. J. Wootton. Academic Press, New York. 416 pp. U.S. $49.

†**The Florida scrub jay: demography of a cooperative-breeding bird.** 1984. By Glen W. Woodfenden and J. W. Fitzpatrick. Princeton University Press, Princeton. c432 pp., illus. Cloth U.S. $45; paper U.S. $14.50.

Frogs of Western Australia. 1984. By M. J. Tyler, L. A. Smith, and R. E. Johnston. Western Australian Museum, Perth. xii + 108 pp., illus. A$9.95.

Handbook of the birds of India and Pakistan: together with those of Bangladesh, Nepal, Bhutan, and Sri Lanka. 1983. By Salim Ali and S. Dillon Ripley. Oxford University Press, New York. xliv + 737 pp., illus. + plates. U.S. $90.

The insects and arachnids of Canada, part 11: the genera of larval midges of Canada, Diptera: Chironomidae. 1983. By D. R. Oliver and M. E. Roussel. Agriculture Canada, Ottawa. 263 pp., illus. $11.95.

Habituation, sensitization, and behavior. 1984. Edited by Harman V. S. Peeke and Lewis Petrinovich. Academic Press, New York. 488 pp. U.S. $59.

Herbivorous insects: host-seeking behavior and mechanisms. 1983. Edited by Sami Ahmad. Academic Press, New York. 264 pp. U.S. $34.50.

†**Maps of distribution and abundance of selected species of birds on uncultivated native upland grasslands and shrubsteppe in northern great plains.** 1982. By H. A. Kantrud. U.S. Fish and Wildlife Service, Jamestown, North Dakota. 31 pp. Free.

The marine and estuarine fishes, south-west Australia: a guide for anglers and divers. 1983. By Barry Hutchins and Martin Thompson. Western Australian Museum, Perth. 103 pp., illus. A$9.95.

†**Nest building and bird behavior.** 1984. By Nicholas F. Collias and Elsie C. Collias. Princeton University Press, Princeton. c360 pp., illus. Cloth U.S. $45; paper U.S. $16.50.

Shorebirds: breeding behavior and populations. 1984. Edited by Joanna Burger and Bori L. Olla. Plenum, New York. c425. U.S. $59.50. Two volume set U.S. $89.50.

Shorebirds: migration and foraging behavior. 1984. Edited by Joanna Burger and Bori L. Olla. Plenum, New York. c325 pp. U.S. $49.50. Two volume set U.S. $89.50.

†**Spatial orientation: the spatial control of behavior in animals and man.** 1984. By Hermann Schöne. Translated by Camilla Strausfield. Princeton University Press, Princeton. c368 pp., illus. Cloth U.S. $55; paper U.S. $14.95.

The structure, development, and evolution of reptiles. 1984. Edited by Mark W. J. Ferguson. Proceedings of a symposium, London, England, 26-27 May, 1983. Academic Press, New York. c700 pp.

Such agreeable friends: life with a remarkable group of urban squirrels. 1983. By Grace Marmor Spruch. Morrow, New York. 187 pp. U.S. $9.95.

Transactions of the Canada Goose Symposium. 1983. Edited by M. A. Johnson. North Dakota Chapter of the Wildlife Society, Bismark. 71 pp.

Wildlife feeding and nutrition. 1983. By Charles T. Robbins. Academic Press, New York. 343 pp. U.S. $31.50.

Wolves in Canada and Alaska. 1983. Edited by L. N. Carbyn. Proceedings of a symposium, Edmonton, 12-14 May, 1981. Canadian Wildlife Service Report Series No. 45. Supply and Services Canada, Ottawa. 136 pp. $12.50.

Botany

Algae as ecological indicators. 1984. Edited by L. Elliot Shubert. Academic Press, New York. 464 pp. U.S. $65.

Grass genera of western Canadian cattle rangelands. 1983. By S. G. Aiken and S. J. Darbyshire. Monograph No. 29. Agriculture Canada, Ottawa. 173 pp., illus. $9.

The growing tree. 1984. By Brayton F. Wilson. Revised edition. University of Massachusetts Press, Amherst. 176 pp., illus. Cloth U.S. $20; paper U.S. $8.95.

†**Oaks of North America.** 1984. By Howard A. Miller and Samuel H. Lamb. Naturegraph Publishers, Happy Camp, California. Cloth U.S. $14.95; paper U.S. $9.95.

111 range and forage plants of the Canadian prairies. 1983. By Agriculture Canada, Ottawa. 256 pp., illus. $11.

Paleobotany and the evolution of plants. 1983. By Wilson N. Stewart. Cambridge University Press, New York. x + 405 pp., illus. U.S. $29.95.

*__Past and present vegetation of the far northwest of Canada.__ 1984. By J. C. Richie. University of Toronto Press, Toronto. 251 pp., illus. $35.

Physiological ecology of plants of the wet tropics. 1984. Edited by E. Medina, H. A. Mooney, and C. Vázquez-Yànes. Junk, The Hague. vi + 254 pp., illus. U.S. $60.

†**The vascular plant flora of Peel County, Ontario.** 1984. By Jocelyn M. Webber. Botany Press, Toronto. v + 94 pp. $10.

Weeds of Alberta. 1983. Alberta Environmental Centre and Alberta Agriculture, Lethbridge. 209 pp., illus.

Environment

†**Acid-forming emissions: transportation and effects.** 1984. By Kimberly Sanderson. Environment Council of Alberta, Edmonton. vi + 52 pp., illus. Free.

An annotated reader in environmental planning and management. 1984. Edited by T. O'Riordan and K. Turner. Pergamon Press, New York. 459 pp., illus.

The bad earth: environmental degradation in China. 1984. By Vaclav Smil. Sharp, Armonk, New York. xvi + 247 pp., illus. Cloth U.S. $25; paper U.S. $13.95.

Biotic interactions in recent and fossil benthic communities. 1983. Edited by Michael J.S. Tevesz and Peter L. McCall. Plenum, New York. xviii + 837 pp., illus. U.S. $95.

Coal myths and environmental realities: industrial fuel-use decisions in a time of change. 1984. By Alvin L. Alm. Westview, Boulder, Colorado. xviii + 154 pp., U.S. $17.50.

Concepts of ecology. 1984. By Edward J. Kormondy. Third edition. Prentice-Hall, Englewood Cliffs, New Jersey. xviii + 298 pp., illus. U.S. $19.95.

Cooling water discharges from coal fired power plants: water pollution problems. 1983. Edited by S. H. Jenkins and P. Schjodtz Hansen. From a Conference, Copenhagen, August, 1982. Pergamon Press, New York. viii + 266 pp., illus. U.S. $40.

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